TOWARD CIVILIZATION

EDITED BY CHARLES A. BEARD

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128 UNIVERSITY AVENUE, TORONTO

LONGMANS, GREEN AND CO. Ltd.
39 PATERNOSTER ROW, E C 4, LONDON
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EDITED BY

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CHARLES A. BEARD

EDITOR OF "WHITHER" MANKIND"

LONGMANS, GREEN AND CO.
LONDON · NEW YORK · TORONTO
1930

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PREFACE

THIS volume, like "Whither Mankind," is a view of modern civilization, but from an entirely different angle. "Whither Mankind" advanced the thesis that what is called Western Civilization, as distinguished from other cultures, is in reality a technological civilization, resting at bottom on science and machinery. In its pages this thesis was discussed and developed mainly by specialists in the humanities — law, economics, and ethics. "Outsiders looking in" reported their findings and impressions.

To a group of prominent engineers in New York "Whither Mankind" appeared to be a challenge to their whole profession. Are not technologists thinkers as well as doers? Are they indifferent to the human aspects of their revolutionary activities? Do they not reflect upon the upshot and outcome of their work? After raising these questions, the group of technicians just mentioned replied that the real leaders of the machine age, men of scientific training and practical occupation, also recognize their responsibility for the future of humanity, see in the materials now at hand the promise of great advances for mankind, and are already seriously considering the drift of things and the nature of the readjustments necessary for a better future.

Hence this inquest. In the pages that follow a group of scientists and engineers inquire into the dynamics of their labors with particular reference to the human aspects. It is a case now of the "insiders looking out." The authors of "Whither Mankind" reviewed the past and surveyed their present. The authors of this book are not concerned with history but with prospects, with work in course. The result is a significant volume — significant as a disclosure of technical tendencies, as a sign of deep stirrings among the members of the engineering fraternity, as the promise of a wider

53397

co-operation among the makers of our machine civilization, as a revelation of the engineering mind to the lay public.

The chapter by Professor Pupin is published by permission from *Scribner's Magazine*, copyright, 1928, by Charles Scribner's Sons.

The editor is under heavy obligation to Mr. George A. Stetson and Mr. W. A. Shoudy, of the American Society of Mechanical Engineers, and to Mr. Frank Ernest Hill and Mr. E. S. Mills, of Longmans, Green and Company, for counsel and assistance in planning and preparing the volume. He also owes a debt to Mr. Elmer A. Sperry, inventor, humanist, and good friend, and no mere words of acknowledgment can pay it.

CHARLES A. BEARD

New Milford, Conn.

CONTENTS

CHAPTER PAGE
Introduction: *Charles A. Beard* 1
I. The New Age and the New Man: *Ralph E. Flanders* 21
II. Science Lights the Torch: *Robert A. Millikan* . 38
III. The Spirit of Invention in an Industrial Civilization: *Elmer A. Sperry* 47
IV. Power: *C. F. Hirshfeld* 69
V. Transportation: *Roy V. Wright* 98
VI. Communication: *Lee de Forest* 120
VII. Modern Industry and Management: *Dexter S. Kimball* 137
VIII. Agriculture: *Thomas D. Campbell* 159
IX. Engineering in Government: *L. W. Wallace* . . 176
X. Art in the Market Place: *Richard F. Bach* . . 196
XI. The Machine and Architecture: *Stephen F. Voorhees* and *Ralph T. Walker* 213
XII. Work and Leisure: *Lillian M. Gilbreth* 232
XIII. Education and the New Age: *William E. Wickenden* 253
XIV. Machine Industry and Idealism: *Michael Pupin* . 273
XV. Spirit and Culture under the Machine: *Harvey N. Davis* 282
XVI. Summary — The Planning of Civilization: *Charles A. Beard* 297

TOWARD CIVILIZATION

INTRODUCTION

By Charles A. Beard

I

THE battle over the meaning and course of machine civilization grows apace, with resounding blows along the whole front. What appeared to be a few years ago a tempest in a teapot, a quarrel among mere "literary persons," has become a topic of major interest among hard-headed men of affairs. A subject mildly discussed in women's clubs has broken into offices, factories, smoking compartments, and political assemblies. No theme, not even religion, engages more attention among those who take thought about life as well as living; no class of thinkers or doers can go far without encountering it. None is so humble that he can entirely escape it; none is so great that he can wholly ignore it. A synthesis of modern aspirations, the very concept of this civilization as destiny and opportunity arrests even the witless; especially invites all who possess the power of brains or money to stop short in their path and consider what work, under the shadow of this challenge, is most worth while here and now.

For many reasons the conflict involves the principal interests of religion. As the concern of the churches about the other world declines in intensity, their activities, directed to the improvement of this, inevitably increase. Since the good life is a fundamental object of their solicitude, they cannot be indifferent to the conditions under which it must be lived. Moreover there is something of cosmic mystery about the creative urge at work in machine civilization, even though demoniacal as alleged. If a new age dawned in the mists of creation when mind gave direction to clay, may not another and greater era open when the power to force nature to human will through science and machinery is brought under the sway of values and ethical potentialities? In the minds of the highest Christian thinkers there has always been a close affiliation, never an antithesis, between spirituality — divine aspiration — and labor with material things.

One of the prime contributions of Christianity to the West was its emphasis on the virtues of labor with material instruments of production, as contrasted with the contempt which the philosophers of antiquity poured upon it. Through the early centuries of Christian teaching, precepts on the dignity of work ran like a strong refrain. Unceasingly the Church Fathers referred to the divine commands of the Old and New Testaments respecting toil, to the example of Christ the workingman, and to the humble callings of the apostles. Amid the unending storms of feudal wars and flashy chivalry, monasteries and convents kept alive by practice and homily the merits and excellence of work in field and shop. It was a fashion among the humbler artists of the middle ages to represent the Blessed Virgin spinning by the cradle of Jesus, Joseph using a saw or ax, and other religious worthies with tools in their hands or engaged in some manual occupation. Many mediæval saints owed their high position to their supposed services in warding off pestilence, causing crops to flourish, or driving away pests — in short, bringing security, comfort, and prosperity to their respective communities. Pasteur and Edison would have been made saints had they suddenly appeared with their discoveries and inventions in the age of Innocent III.

Why then should it be assumed that the creative activity of the engineering era is necessarily a break with the past rather than a continuation, on a grand scale, of cosmic labors begun when the seas were separated from the land and squirming life appeared in the waters? Experience and such reason as we have bid us hold to the unity of all things. Even an event, as Whitehead says, is an organism and the earth itself has been held to be a worthy place for the kingdom of heaven.

In this continuous creative process which produces and sustains our machine civilization, all take part, whether they work or buy or criticize or amuse themselves; all are in some intimate way directors of it or victims of it, twist and turn as they will; to its inescapable imperatives they must conform. And at bottom all, or nearly all, are alternately hopeful and pessimistic about it; they both cheer and curse it. As they observe the wireless radio encompassing the earth with music or the airplane soaring in the sky they marvel at its wonders; caught in its daily routine, its grinds, and its traffic jams they damn its tyrannies and futilities. At one hour it seems big with destiny; at another heavily laden with absurd telephone calls and vain irritations. But they cannot escape it. Day and night it encompasses them. Whoever would fain accomplish great things must somehow co-operate with it. A coming to consciousness of its drives and its choices in itself marks the appearance of a new power.

If, as some critics urge, science and machinery were abandoned, if a few hundred thousand engineers (out of the earth's teeming multitudes) should quit work for good, as Spengler truly says, the whole structure of modern society would come down around our ears. Great cities would sink into ruins and grass would grow in their streets. Telegraph and telephone lines would cease to hum with messages; railway lines would fade away in rust; water would no longer flow at the faucet and the wastes of the city would block its sewers. Electric lights would go out and darkness fall at night on the whitest of the White Ways. The daily press gathering the news from the four corners of the earth would disappear. Ocean liners would stop on the high seas and drift like chips of wood before wind and wave. Epidemics such as the Black Plague would sweep through whole continents leaving festering death in their train.

No section of the modern world would escape the impact of the crisis. Even agriculture, the most primitive of the economic arts, would be paralysed for want of implements and markets. Esthetes writing under soft lamps in steam-heated studios about the necessity of recovering humanism and religion would be sent scurrying to the nearest forest to gather twigs with which to warm their blue hands. Africans toiling on rubber plantations in the tropics, now stripped of tribal habits and cunning, would sit helpless before the nature that once nourished them. Imagination is not powerful enough to draw a picture of the new chaos that would follow the disappearance of science and engineering, for mankind could not quickly (if ever) recover the culture of primitive life, and experience would throw little light on the contingencies hidden beneath such a world-shaking transformation.

II

Nevertheless this machine civilization is under general indictment as the foe of all values, human and divine. Although feudal and clerical Europe is rapidly being transformed in its image, America is chosen by the critics as the best illustration of the evil they resent. But if America, as they allege, represents in their minds not a nation but a symbol, still it is fitting that in the New World, rather than the Old, the challenge should be met and the issue probed to the bottom.

Sponsored by writers of undoubted power and great vogue — Belloc, Chesterton, Siegfried, Santayana, Keyserling, and Müller-Freienfels, for example, the charges brought against machine civilization must be squarely faced. Dismissing them with a shrug or a gesture will not dispose of them or dispel the effect of their criticism in the contemporary mind. Great enterprises, whole systems of economy and government, have been dissolved by a loss of the faith in their values, which sustained them.

Naturally the starting point for the discussion of the problem thus raised is the bill of indictment itself, summarized from the papers of the self-constituted jury of inquest.[1] Until the charges are squarely presented, of course, the issues cannot be fairly joined. Unless the issues are directly joined, the terms of debate brought to a focus, no intelligent judgment can be rendered in the celebrated case arranged in modern criticism under the head of Values *versus* Things.

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[1] Especially Keyserling, *Travel Dairies*, and *America Set Free;* Siegfried, *America Comes of Age;* Aldous Huxley, *Jesting Pilate;* and Müller-Freienfels, *The Mysteries of the Soul*, in particular the chapter on "The Americanization of the Soul" which is extensively quoted in this Introduction. Stuart Chase, in *Men and Machines*, seeks to formulate a balance sheet of "good and evil."

First upon the bill of indictment is the allegation that modern civilization "quantifies" life, uses mathematics to measure all good. "*Quantity, in America,*" says Müller-Freienfels, speaking for Europe, "*is not a fact, as with us; it is a value.* To say that something is large, massive, gigantic is in America not a mere statement of fact, but the highest commendation. The idyllic frame of mind which sees positive value in small and restrained and limited things is un-American. . . In America everything big is blindly accepted. Magnitude, in the purely external sense of largeness, sets the standard of value. . . The millions of the wealthy receive the same homage as titles and orders in Europe. Social position is determined by the size of a man's bank account. . . The American has no perception of the incommensurable."

But this quantification is merely a reflection of a deeper cause — the mechanization of life: Item Number Two on the bill of indictment. Under the machine the human soul is rationalized. By rationalization is meant "the prevalence of practical thinking, of the concentration of the intellect on the practical, useful, and efficient, and the obverse of this attitude is the repression and suppression of all that is merely agreeable, emotional, and irrational in the personality. . . Man himself is becoming mechanized, is considered solely with regard to his performance. What are the holders of the great athletic records but machines for boxing, playing baseball, or running? And the workers in the factories? They too are machines, which indefatigably exercise the same function, a function rationally acquired, without personal relation to the thing which they are making. . . Strictly speaking the factory worker is not even a complete machine, but only a portion of a machine, with no more independence than a cog or a driving belt. Taylorism and Fordism are the systematic accomplishment of this mechanization of the human being. If we now take a rapid survey of Europe and the rest of the world, we find everywhere the same tendency to mechanization and technicalization. . . In respect of the tyranny of technique, we are becoming more and more Americanized."[2]

The machine, we are told in elaborations of this argument, is utterly indifferent to the human element — to labor — treats it as a quantity; so many hands, so many hours, so many units per hand-hours. (It may not be impertinent to recall the fact that the term "hand" comes from the agricultural age.) The machine chains man to his working process, deprives him of initiative, draws out his energies (heat units), and then in times of business depression, certainly in his old age, throws him out a wreck upon the tender mercies of society. Indeed it may supplant him in middle life by new labor-saving devices and leave him stranded, a forlorn derelict, possessing an obsolete technique, helpless amid a jungle of whirling wheels that heed him not. It maims him in accidents, deafens him by clangor, houses him in monotonous slums, removes him from organic connections with nature — soil, rain, trees, and green grass — and offers him only mechanical amusements in his leisure hours. When "hands" are treated as quantities, the human spirit withers.

This subdual of life to mechanical performances reverses the order of nature — turns mankind upside down. "Technique is not, as it should be in theory, a means to an end, but is becoming an end in itself. The clatter of machinery, which we find disturbing, is music to the true American ear. . . I was repeatedly taken to see wireless apparatus, which reproduced the greatest variety of messages with a considerable amount of noise. What was heard, whether Beethoven or jazz music, did not interest my hosts in the least; all that they considered was the technique of transmission and reception — technique as an end in itself."

From the conquest of industry by mathematics and mechanics results inevitably the standardization of all life, outside of industry as well as inside. "If you go shopping you will find everywhere the same standard wares in the window. All men seem to be clothed by the same tailor, and all women seem to have bought their hats at the same shop. As a matter of fact, they buy the same things in different shops. Everything reaches a most respectable standard, but everywhere this standard has the effect of a levelling, a standardization. The most remarkable thing is that even the people impress one as having been standardized. All these clean-shaven men, all these girls, with their doll-like faces, which are generally painted, seem to have been produced somewhere in a Ford factory, not by the dozen but by the thousand. In no other country are the individuals reduced to such a dead level as in the United States. . . Human typification finds an esthetic expression in an 'ideal beauty,' which is propagated daily in a thousand magazines, kinemas, and theatres, and from which all the characteristic differences of race, sex, age, and class have disappeared." In a word, the tyranny of standard has destroyed personality.

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[2] The French writer, Siegfried, with reference to the idea thus expressed by the German critic, Müller-Freienfels, says: "In nothing does America more resemble Germany than in this discipline of thought. It may lead to splendid material results and it is undoubtedly a marvellous aid to economic achievement; but under it originality and individual talent, and often art and genius, rebel or are stifled. France has the same instinctive fear of American methods as symbolized by Ford as she had of the German system on the eve of the War."

With the mechanization of life comes a revolution in ethics — under the machine, morality is not a matter of the inward spirit but simply of external conformity to the *mores* of standardized masses — a morality of material utility and success. This constitutes another item in the bill of indictment. The machine man, typified by the American in particular, "believes his superficial humanitarian morality to be the absolute morality; not for a moment does he doubt its general validity. . . Morality is the normal good behavior of the typical citizen or bourgeois. In the artistic circles of Europe the title of 'bourgeois' is almost a term of abuse; on the other side of the Atlantic 'citizen' is a title of honor. If one were to say in France or Germany that so-and-so was a 'good citizen' *un bon bourgeois*, one would imply that he was something of a Philistine; the term would be employed ironically; but in America it is a commendation that may be heard at every turn. . . If you wear a hat that is unlike your neighbor's, or prove refractory to the moral cant of America, or express your own ideas, you will be in danger of becoming a social outcast." Motives do not count, inner spirit is worthless; it is conformity to mass standardization, to convenience, that counts as value in a machine civilization.

This item in the bill of indictment thus formulated by Müller-Freienfels is given a more drastic turn by Aldous Huxley in his criticism of the ethics of "Service," another slogan of the machine age, borrowed from feudalism. "For Jesus and St Francis," he says, "Service connoted self-sacrifice, abnegation, humility. For the morticians and other American Business Men, Service means something else; it means doing profitable business efficiently, with just sufficient honesty to keep out of jail. American Business Men talk like St. Francis; but their activities are indistinguishable from those of the money-changers and sellers of doves whom Jesus expelled from the Temple with a whip of small cords. The money-changers and the bird-hawkers protested no doubt that they were serving humanity as well as, even better than, their aggressor. . . It is on the same ground that they perform necessary jobs well—that American Business Men claim to be doing Service, and Service of the highest value. They overlook the significant historical fact that all the valuable things in life, all the things that make for civilization and progress, are precisely the unnecessary ones. All scientific research, all art, all religion are (by comparison with making coffins or breakfast foods) unnecessary. But if we stuck to the merely necessary, we should still be apes." To put it in another way, mere outward conformity to standards of utility is not morality; it may be cowardice; service without sacrifice is a fraud.

If morality is conformity, if values are merely quantitative, if the man with the most goods is the most highly regarded, then it follows that in politics the democracy of balloting-equality is a delusion. The logic of this conclusion has not escaped the formulators of the indictment here summarized. It is a prominent number on the bill. "In America it is not really the mass of the equalitarian Demos that rules, but an oligarchy of dollars and technique. That man is a ruler in America who possesses money, railways, mines, and a press. This is not felt to be inequality, as a nobility of birth would be, because every American believes that if he had luck he might one day acquire these means of power. And the oligarchy is cunning enough ever and again to remind Demos, to suggest to him, to hammer it into his brain, that the people governs by means of the vote, whereas in actual fact the vote is controlled by the press and the money." If there is fundamental truth in this allegation, can democracy function under the machine? If it cannot, what is the alternative?

It is not merely mundane things that are ruined by the machine man. Higher creations of the spirit are transformed or stifled. Machine civilization, typified in the United States, we are told, brings forth no great art. "It must be admitted that what America has produced in the way of native art, poetry, and music (in the European sense) is little enough in comparison to the size of the country and that even where people do concern themselves with art an inartistic spirit prevails. . . The artistic impulse in music, drama, fiction, dancing, architecture, and sculpture is governed by the endemic principles of quantity, mechanization, and standardization. Art is capitalized, democratized, and standardized. The spirit of the record, of the mensurable best performance, prevails in art as it prevails in industry and sport." Something new may be coming up through the heap of angles and "the smooth, saccharine ideal of American beauty," but it has not yet arrived.

Against no creation of the machine is the esthetic indictment more often lodged than against the industrial city — the Birminghams, Essens, and Pittsburghs of modern civilization. It is a horror, we are informed, a wilderness of brick and mortar, a smudge of smoke, grime, soot, and squalor; the sunlight is obscured or if perchance it breaks through the pall it cannot reach the dark rooms of the city's canyons. The very air is foul with fumes and gases. A blight falls like a curse upon the vegetation. Urban architecture is at best anarchic; if a genius does erect a monument of beauty, it is certain to be blasted by neighboring monstrosities. The checkerboard lay-out of streets, with its dull monotony, makes impossible grand vistas and inspiring scenes. The only reason why the urbanite can endure this nightmare is because "the cosmic beat in his being is decreasing,"[3] and he is sinking down into the vegetable, perhaps, the mineral kingdom. If he rejoices in the city it is merely a sign of his physical degeneration.

[3] Spengler, *Decline of the West*, Vol. II, p. 102.

Even pure science, the noble spirit of curiosity, disinterested inquiry into the natural world, the quest of truth for its own sake, is under the blight of mechanical utility. American scientists are dominated by the mathematical and practical. "Americans have little esteem for the research-worker who seeks knowledge for its own sake. . . This is apparent even in the exact sciences. Even the patriotic American will be forced to admit that the great discoveries in theoretical physics and chemistry are made in Europe." America's contribution to philosophy, pragmatism, partakes of the psychology of salesmanship. "It is optimistic, and inspired by action. If the truth is a guarantee of work and creative activity, what more can one desire? Let the world be what it will: the American pragmatist does not doubt that he will be able to shape it as he finds it agreeable, to give it the form that he needs, in order that he may labor in it." America's contribution to psychology, behaviorism, is nothing but a branch of the mechanics of biology and conformity. Twist and turn as he will, the American thinker is under the spell of the numerical, the measurable, the quantitative and hence cannot penetrate to the heart of things — life, destiny, eternal values, etc.

Then what of religion under the machine? That, too, it is alleged, is transformed in the image of utility and mass production. The soul of man is depersonalized, denaturized. The machine man is dominated by rationality, the practical and the prosaic, "which conditions his external success in technicalizing, mechanizing, and standardizing life. But this rationality must not be confused with *intellectuality*, with *spirituality*, in the European sense, if by this one understands absorption in the profounder scientific, artistic, and philosophical problems of existence. In this sense the American is *un*spiritual, *un*intellectual, *un*philosophical. Problems do not interest him." Religion is powerful in America only because it has been emptied of its historic content and changed into a religion of optimism. "It may decorate itself with mysteries as it will, it is simply a deliberate optimism of the surface." Christian Science, America's contribution to religion, is the philosophy of "healing," of escaping discomfort, of prosperous living, which is the aim of applied science and mass production. The machine is God, and Mr. Bruce Barton is his prophet!

This programme of damnation is discouraging enough, but to crown it all we are told that the machine threatens a destruction of our natural resources (upon which industrial processes rest) and that another world war of machines and chemistry may wipe out all Western civilization, the good with the bad. Mr. Stuart Chase has formulated the indictment of waste and, in the same breath, expressed skepticism about the ability of the "miracle-makers of science" to repair the havoc they have wrought. In any case a problem and a peril must be faced. Nor is there any doubt about the nature of the next war, "if it comes." A thousand voices bring warnings on this score. Mr. Raymond Fosdick wonders whether "the old savage in the new civilization" will not pull the whole house down on his head. If the makers of science and machinery have in reality spread throughout the world the evils enumerated in the above bill of indictment, then perhaps poetic irony would require their destruction at the hands of their own Frankenstein.

If unjust here and there, if exaggerated and overemphasized in detail, these charges are not merely captious or irrelevant. If they hark back to a buried past, they are not wrong, for the unity of history and culture is never sharply broken. At all events intelligent persons are giving heed to these criticisms, are wrestling in spirit with the problems raised by them, are deeply impressed at least by the partial truth that inheres in them. No human being far above an oyster in mentality can fail to recall, as he reads them, horrible examples from life and experience to illustrate them — New York City from the elevated railway, huge sections of Pittsburgh and Chicago, shabby and dilapidated water fronts, glorious spots of nature made hideous by factories, endless rows of monotonous dwellings, the shameful disregard of beauty along the highways from Boston to San Francisco, magnificent avenues through forest and valley ruined by billboards and gas-filling shacks, fretful masses rushing from one mechanical show to another, the horrible outpouring of radio nonsense, natural and canned, the unceasing roar and grind of urban life.

Thousands who do not rest their jagged nerves in quiet country houses, who must spend their waking and sleeping hours amid the dust and stews of the city, feel that, with all this chatter and rattle about prosperity, life is lacking in security, in richness, in sweet contentment, and in the joy of inward contemplation. Amid the plethora of goods turned out by the machine they remain unsatisfied in soul, encounter no great exaltation of spirit. A man driving a motor a hundred miles an hour, heedless of peril, may be no better or wiser than a pedestrian trudging along a shady country lane. A woman with fifty dresses and sixty pairs of shoes is not necessarily greater in spirit or nobler in action than John Adams' Abigail. Hence multitudes, hearing the voices of the critics, do ask here and now: What is all this worth?

These questioners and doubters constitute a second line of objectors not to be ignored. They accept science and machinery without bowing down blindly before the calf of steel and concrete. They recognize a certain inevitability in the current development and see immense potentialities in it, but wonder whether the new Leviathan has not got entirely out of the control of its makers. They are inquiring whether engineers and scientists are at present a lot of small fellows doing great things dimly understood or are big men capable of heroic and highly imaginative enterprises, if set free. They do not believe, with the intransigents, that civilization is a kind of loose garment that can be put on and off by esthetes and connoisseurs at will, that evils are always perversities arising from wicked desires; on the contrary they think that civilization is in deep and tangled ways a part of and a reflection of the work that people do. They admire the Gothic cathedrals and handicrafts of the Middle Ages, the divine loveliness of Chartres and Sainte Chappelle, and wonder whether a kindred glory, in a different way appropriate to our age, cannot emerge from the work which engineers have opened before mankind. They do not want anybody to withdraw to Thoreau's solitude, but they seriously and insistently ask: Who is to soften the harshness of the machine, humanize its functions, and crown days of labor with peace no less than plenty? And how is this to be done? Will the captains of our fate pause in manufacturing by the train-load to consider these questions? Will they co-operate heartily with seers who approach the problems thus raised from other angles than those of mass production?

III

ALTHOUGH engineers and scientists are not always specifically named in the bill of indictment, they are undoubtedly among the accused at the bar and cannot escape the duty of taking thought about the charges that confront them. Are they, as claimed, merely robots of their own creations, servants not masters of the machine, doers not thinkers? Are the inventors, operators, and extenders of machinery in truth more indifferent to values, human and divine, than warriors, priests, and aristocrats of blood (and land and iron)? Is it true, as Veblen says, that the technologist has no "canons of validity" at all, that these are purely cultural in origin and sanction? In final analysis are all values — moral, esthetic, and religious — to be left to the determination of literary critics, artists, and abstract philosophers standing outside the machine process itself? Surely, those are questions of importance. Every other class in history — landed, bourgeois, and laboring — has created its own ideology, its world of values, ideas, and symbols. Editors claim to be a kind of fourth estate in modern civilization. Technologists are not an exception to the universal rule; will they assert their right to be considered as a fifth estate in the modern order, perhaps the first?

Certainly they are the best fitted by training and experience to report on the tendencies and possibilities of the machine system. They can tell us whether the esthetic and moral offenses developed in industrial society are permanent and inescapable accompaniments of their enterprises or are merely temporary evils due to the crude beginnings of the early stage. It is well to remember, after all, that the steam-engine burst in upon an agricultural world with an intellectual, esthetic, and moral heritage of its own. It was in an ethical and religious order to which many critics of the machine process would fain return that the engineer began his work, and perhaps some of the worst evils that followed his early operations are to be attributed to the weakness of the old heritage rather than the nature of technology itself. Whether the spirit of science, which is responsible for our magnificent machines, can conceive of a magnificent society is a problem in technology.

Whatever evils in our civilization may be legitimately ascribed to science and the machine — the noise, congestion, ugliness, grime, discomfort, and distress of the ill-planned city, for example — the task of removing them is an engineering undertaking. They spring from arrangements of materials; their removal calls for the re-arrangement of materials. Poets and philosophers may dream dreams for human society, youth may see visions, but the realization of their aspirations hangs upon the capacity and understanding of the engineer. Upon his nature, competence, and hopes depend all achievements in reconstruction. Architects, artists, and planners of civilization must convince him; he alone can tell them what is possible in the management of power and materials. Without his co-operation all others are mere builders of cloud castles. Many things he himself can do now in the work already under his hand; greater things he could accomplish if he had larger vision; immeasurable things lie ahead, if with him and his technique were associated all the high imaginative forces of modern civilization.

When true to his vows, the scientist is peculiarly competent to deal with the issues which vex the humanists, is under obligations to consider them, must face them if he is to make the most of his own powers. He does not cease to be human because he works with materials; the artist must study anatomy, physiology, the chemistry of color, and the composition of light. The scientific method does not stop at physics and chemistry; nor is cold rationality its only instrument of research and operation. Some of our greatest inventors and scientists have confessed to the uses of imagination and intuition — artistic perception — in making discoveries of practical utility and the highest philosophic value. Science has not cut loose from humanity and its heritage. "Always," says Spengler, "science has grown up on a religion and under all the spiritual prepossessions of that religion. . . Always it carries along the kernel of a religion in its ensemble of principles, problem-enunciations, and methods." In other words, the technician, besides being a specialist, works in the general process of civilization with all its intellectual instrumentalities, and cannot be cut off permanently from organic relations.

Heir of the past, path-breaker in the present, the engineer, by virtue of his labors, is in a strategic position to make a survey of the civilization in which he is a creator and seeker. He is at the very centre of the machine process. On the basis of his intimate experience he can inform the layman about the forces inherent in it, its probable direction, and its potentialities subject to human control. The engineer, as Spengler says, is the priest of the machine, the man who knows it. "His thought is as possibility what the machine is as actuality." Suppose, Spengler continues, engineers should decide that their work was not worth while, was in fact "Satanism," and should take to mysticism and metaphysic, then nothing could hinder the smash of the grand machine-drama. But suppose (and one guess is perhaps as good as another) engineers find not satanism but divinity in their work, then they might transform the world in the image of something higher than was ever dreamed of in the past. At all events for the present (and it is sufficient) a knowledge of the direction and potentialities of the machine process, both its inevitabilities and flexibilities, is necessary to co-operation between technicians and laymen in the adjustments that can be made in the interest of the good life and esthetics.

And there is no doubt that the real makers of machine civilization will give increasing attention to the values inherent or implied in their work. Under what seems to be a law of intellectual evolution, they will turn in upon themselves, seek to evaluate the upshot and outcome of their labors — deeds no less than thought engender reflection. Deeds produce ideas; they evolve together, with reciprocal and cumulative effect, as William James contended, and cannot escape the iron embrace in which they are locked. Although engineering journals are still crowded with technology, with graphs, diagrams, formulas, and mathematical calculations which are mysteries to laymen, there are many signs that the engineering fraternity is on the eve of a great intellectual awakening. Flashes here and there, activities hither and yon, the formation of a National Council of Engineering Societies, attacks on the profession inside and outside for narrowness of preoccupation, unrest over the basic schemes of technical education, all these things indicate that engineers are coming to a fuller consciousness of their mission, rôle, and responsibilities in the civilizing process. Warriors, priests, statesmen, and philosophers have had their day, have not yet ceased to be, and in the fulness of time the engineering army will come upon the world stage to measure its strength with the problems of power and destiny in front of mankind.

When scientists and engineers enter upon the larger way, they will cease to turn on their critics, saying: "You have abused the instruments we have made." Although there is truth in the retort, yet upon the designer and builder rests a large part of the responsibility for the choice of place and materials and the methods of the doing. He cannot escape his obligations by crying out that the upshot is none of his business. Perhaps in the end, the defenders of science and machinery will be the most formidable and effective critics of these instrumentalities of the modern age, and when the avalanche does start to move, machine civilization may prove to be strangely plastic, not a stereotype. It may turn out that those who love and understand the test tube and the engine will be masters in the end — great masters not unworthy of standing beside the artists and builders of old. "Technology," says Zschwimmer, "prepares the ground. It offers to the people the powerful instrument of its creation: the instrument for forcing the world under human will. However it now demands real, born conquerors of the world — conquerors by the grace of God! . . . We technicians await a generation that will show itself worthy of this great creation."[4]

Proof of the fact that mechanical work is actually being permeated by a new spirit is made evident by contrasting current thought about it with the thought of the eighteenth century epitomized by Wingfield-Stratford in the following passage describing the early stages of the Industrial Revolution in England: "For the typical industrialist the quantity of things produced, not the quality of life, was the supreme end to which he was ready to sacrifice himself and everybody connected with him. In the eyes of his economists, productive capital was that which went to produce more capital; unproductive capital was that which went to beautify and sweeten life. As the old Puritans had knocked glass out of church windows and statues from their niches, so these new iconoclasts of progress treated all that did not directly conduce to the maximum of production at the minimum of cost. They had no time to philosophize or look ahead, they had a faith, a faith as blind and trusting as that of the sternest saint, in the providence that orders all things together for good, for economic men. Let Mammon arise and let his enemies be scattered! . . .

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[4] *Philosophie der Technik*, p. 166.

"Nobody had any object in building [industrial] towns but to get some sort of shelters run up, as quickly as possible, beneath which the men, women, and children who served the machines might get a little brief sleep to recruit their energies. As all was done by competition and on a basis of quick returns, not only beauty but health and ordinary convenience were allowed to go by the board. Such a thing as intelligent town planning was undreamed of. The unhappy 'hands' were crowded together, deprived of sunlight, breathing smoke into their lungs, in the stench of open drains, and without their eyes being able to rest on anything but the meanest and most restricted prospect — for even the sky was darkened."

It is only necessary to look upon this picture and contrast it with the finest results of industrial and architectural planning to discover that a revolution may be wrought in machine civilization when the makers of it set to work under the full light of emancipated imagination.

For the editor of this volume this possibility was concretely illustrated by his experience as an associate of the late Count Goto, Home Minister and head of the work in reconstruction in Tokyo after the great earthquake and fire of 1923. Two-thirds of the city was in ruins, levelled to the earth. A board of engineers, architects, and city planners was commissioned to design a new city, combining technology and esthetics in a balanced picture. These leaders had at their command the lessons of the civilized world. They could design and build. The spirit of old Japan and a vision of the new age were in them. And with splendid enthusiasm they rose to meet the emergency and the opportunity. Whatever their limitations, if they could have had their way, they would have transformed the ancient city into a marvel of beauty and efficiency (for the two are not foes). Great work was accomplished, but not enough. And the failure in realization must be attributed to the esthetic and intellectual unpreparedness of the citizens rather than the desires of the technicians. The ground had not been sufficiently broken by the combined labors of physics and philosophy. Separated by tradition, they could not suddenly be united in a perfect harmony by a single crisis. Perhaps both parties were to blame for this state of affairs, but the technologists were more willing in spirit than the multitudes whom they served.

IV

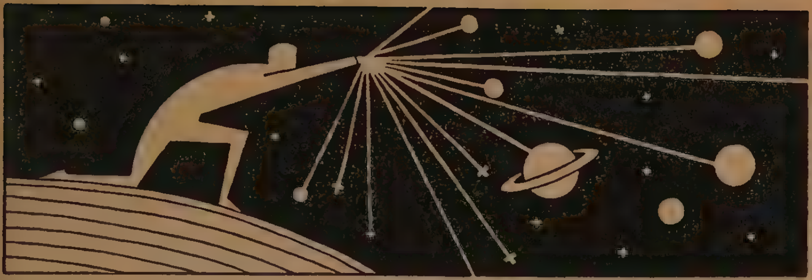
HERE then are the issues. Here are the high parties to the case at the bar of opinion, where world history, as the Germans say, serves as the world court of last appeal. Now, at law there are many ways of meeting a bill of indictment. The charges may be categorically denied; then proof must be forthcoming. They may be admitted and a demurrer filed to the effect that they do not constitute wrongs as alleged. They may be offset by countervailing and extenuating circumstances that render them irrelevant. They may be conceded in principle and parried by a promise of abatement and reformation.

To some extent these procedures may be adopted in the case of Values *versus* Things. But on the whole the analogy is misleading. Is it possible to find judges standing above and outside the controversy and yet competent to render a true verdict? Are the contestants who have lodged the bill of indictment wise and dispassionate enough to act as referees in their own cause? Can the issues be disentangled from the clashes of classes, religions, and nations for consideration on their intrinsic merits? And who is to lay down the law governing the case?

Certainly these are disconcerting questions for all who rush into the fray thinking the matter simple in nature. Yet it must be admitted that a fair discussion of the issues will clarify them, will help to educate the participants by softening their angularity, will illuminate ways of life for observers. And doubtless neither party will emerge from the contest unscathed; the outcome will be different from the intention of each; there will be a fusion of ideas and ideals from both sides, a transformation of the contestants themselves. For the blending of destruction and construction, negation and creation, inheres inevitably in the world process itself.

If reflections may be introduced by a mere editor, then two points apparently pertinent to the case deserve consideration. The first is that the process of mechanization is increasing in speed and widening its geographical area. It is by no means confined to the United States; it spreads to the uttermost boundaries of the world. Even the severest critics of the tendency admit that. Many of the Europeans who deplore it concede its momentum and merely appeal for a counter-revolution. Since this is true, it follows that our philosophizing, teaching, preaching, and aspiring in the future will have to take note of the extension of the machine process. What inventors and operators think about the nature of their work, about the forces inherent in it, about the directions of its expansion, is accordingly of the highest importance as an indication and as a source of creative efforts. It is time that they were heard from.

A second point pertinent to the case in hand is the fact that the most ardent critics of machine civilization believe in religion as a source of values — in the existence of an underlying spirit, in the divine government of the world. Then it would seem from their indictment that the heavenly hierarchy is letting an ever larger proportion of the human race escape from control, is indifferent to the course of things, is powerless to change it, or predestined it in the beginning. Their other available assumption is that the Devil is gaining, is getting not merely the hindmost, but the leading participants in the grand procession. In either case the dilemma thus presented must be distressing to critics. It might be more in keeping with their assumptions and convictions to accept the central advance of the machine process as a great demiurgic movement, with new values in the making — a process continuing the old tendencies of Western civilization on a new level, on a scale more vast, with a possible humanistic upshot transcending the historic ideals of caste — literary, artistic, political, and religious. At all events it is fitting that scientists and engineers, the makers, directors, and expanders of the machine process, should be given a full day in court.



I — THE NEW AGE AND THE NEW MAN

By Ralph E. Flanders

I

IN SEARCHING for the forces which have shaped our modern world we shall find three that have exerted a decisive power. They are first, the freedom of thought which derived from the Renaissance and the Reformation; second, the development of science and the scientific method; and, third, the similar but separate growth of invention.

All of these had stirred the human imagination as early as the first years of the sixteenth century. Yet if the printing press was already busy then and Luther was soon to speak, and if the first crude microscopes and the first of modern philosophy were not far away, the form of the earlier world was still to envelop mankind for centuries. Bacon, writing his amazing "Novum Organum" in the early 1600's, saw about him a world awaiting deliverance, and his somewhat inarticulate prophecies have long since then been exceeded by truth. The Renaissance world was linked unit to unit by muddy highways and fragile wooden ships. It was the slave of infinite infections, heatless and lightless houses, man-power implements, and news that went by boat or horseback. The modern world of concrete roads, intricate factories, steam-heated offices and houses, words tossed by air or wire across seas and continents, armed scientific battalions routing pollutions and fevers — this world would have seemed a sun to its candle, a thunderbolt to its crude leaden bullet.

The modern world began its really firm and rapid growth in the eighteenth century. In science, Copernicus and Galileo had described the solar systems, Newton had announced the laws of gravitation and studied the theory of light, and he and Liebnitz had developed the infinitesimal calculus. After these events came an active blossoming of invention. Watt with his steam engine, Arkright, Hargreave and others with their textile machinery, and finally Fulton and Stephenson with the steamboat and locomotive, revolutionized manufacture, transportation, and commerce. A new figure, the industrialist, seized on these inventions, capitalized and multiplied them for his own profit.

The scientist began the revolution in man's thought and philosophy, while the inventor changed his whole material environment. These two agencies, both working to the same end, were practically independent. The scientist's work led to few practical applications, the inventor depended on "rule of thumb" and availed himself very little of the scientist's discoveries.

About the middle of the nineteenth century a change in relationship was well under way. Science and invention were joining hands. Their lusty issue was Engineering, which has grown to overshadow completely its parents, so far as material achievements are concerned. Science which is "pure" is getting further removed from immediate practical applications, and seems to be approaching the boundaries of philosophy, religion, and mysticism. Invention of the non-scientific sort, meanwhile, has not disappeared, but is playing a smaller and yet smaller part in transforming modern life.

As the outstanding material forces of our time, we would probably select the steamship, the locomotive, the telegraph, the telephone, the automobile, the airplane, and the radio. If we examine any one of these in detail — the ocean steamship, for instance, we find a moderate amount of non-scientific invention in its minor details; we discover a deep foundation work of bygone pure science in such matters as the "Carnot cycle" and "Joule's equivalent" in thermodynamics, and in the premonitions and final discovery of the radio wave by the combined work of Faraday, Clerk Maxwell, and Hertz. But overwhelming and burying all is that vast mass of intelligent, patient, keen analytical work, combining in its operations intuitive invention and scientific research, which goes under the name of "Engineering." Tens of thousands of engineers, in laboratory, drafting-room and work-shops, in an unparallelled co-operative enterprise which has stretched over generations and knows no boundaries of race, language, or religion — all this it has taken to build the ship.

A spring night on the boat deck, a dark sky sparkling with stars, a gentle phosphorescence in the bow wave and the wake . . . Breathing quietly, the great ship heads for its appointed land-fall, bearing its appointed freight of merchandise, mail, and men. There is the feeling of life in it, of accepted responsibilities — as if it were some massive, faithful, intelligent animal. That sense of life, of faithfulness, of intelligence is no illusion. It is the re-embodied life, faithfulness to natural law and intelligent co-operation of the engineers and artisans whose concentrated efforts have given birth to this wonderful, effective creature.

The new man, the engineer type — whether he is a directing executive, a practical laboratory scientist, or an inventor — cannot refuse responsibility for this brood of vital mechanisms which has grown from his work and has fashioned the world he operates. He has wrought the intricate framework of the machine age; he has an obligation to society for his product.

And the product, bringing mankind tremendous power, has brought certain evils.

The first century of industrialism is not a pleasant chapter in human life. The dark factories and mills, the long hours and iron routine for small wages have warred against human happiness; they are hateful things to contemplate, and in a measure they still exist.

Again, the machines have brought us ugliness. Not only is there the subtle ugliness of many machine-made articles (particularly painful in the product of the punch press, for some strange reason), but there are as well the more blatant manifestations of din, dirt, grime, and confusion which attend many of our major industries. A Pennsylvania coal town, a New England cotton-mill city, a dry-grinding cement mill, a copper smelter, the Chicago Loop — none of these is a centre of sweetness and light, and they are all children of the engineer's brain.

Nor are the noise and crowding, the sunless chambers and the subterranean rabbit holes of our megalopolitan civilization desirable achievements. The self-hypnotized citizen may gesticulate himself lame and shout himself hoarse, but even so he shall not completely convince himself that quietness, space, green herbage, white snow, and blue sky are not essential to fulness of life here on earth. The extreme forms of noise and crowding in our great cities condemn themselves, and the new man has brought them to us. Consider but this one item: In a city in the suburbs of New York there was developed a new mechanism for carrying people in a vertical direction. It was christened the "traction elevator." It was very simple, but had the remarkable virtue of making it possible to transport several times more people through an elevator well several times longer than had previously been possible. This simple development at once started the already invented steel skyscraper to growing like Alice in Wonderland with her magic mushroom. And with like magic sprang into being that eternally proliferating and eternally inadequate web of subways, tunnels, bridges, traffic regulations, real-estate booms, apartment Babels and taxi-cab wars which constitutes the normal transportation problem of the great city. Thus does the absorbed and harmless appearing engineer strike the match that lights the fuse that explodes the mine beneath the old urban peace and complacency.

Finally, the engineer's work has in general led to a narrower, more concentrated, more intense, and less well-rounded existence for the mass of mankind and particularly for the more able among them. The vastness of the bulk of accumulated technical knowledge demands that the able man shall specialize if he would be effective. The character of the technical processes themselves requires that workmen shall specialize. Also, the competitive conditions which have arisen out of this technical complexity demand that both unusual and ordinary men shall concentrate on their tasks to a degree that is often wearying and sometimes dangerous.

The new man can justly refuse to take the full responsibility for such evils. A selfish and doctrinaire political economy must share the blame. So must the darker side of our general human nature, which has been no more grasping and inhuman in coal mines and cotton mills than it was in the African slave ships or the sheep-raising crises of Tudor days. The apathy of a public which could protect itself if it would has also been a factor. Yet the engineer, creator and operator of the apparatus which directly or indirectly has brought the world these miseries and indignities, must frankly admit his share of blame and his obligation to modify or remake that which misfunctions.

II

BUT ENGINEERING has also certain positive gifts to its credit, and certain resources which need only be understood to be appreciated. They are, indeed, of such potential value that the highest hopes of mankind for the present life may well lie in the proper comprehension and application of them.

The first resource which engineering has to offer is its proved practical effectiveness. Engineering may be defined as *science which works.* In the same category may be placed chemistry, also much of modern surgery and a great part of modern medicine — particularly preventive medicine. Classing all of this somewhat rudely, but conveniently, under the one term, an outstanding characteristic of engineering is the almost uniform successfulness of its undertakings. There have been practically no serious failures. The only two which come to mind are the collapse of the partly finished Quebec bridge in 1908 and the failure of the storage dam of the Los Angeles water system last year. The first of these was due to an obscure factor in the calculations of the compressive stress in beams of unprecedented size, unsuspected by one of the world's greatest engineers. The second was due to an unpardonable carelessness on the part of a municipal engineer in the examination of the rock on which his dam was based; and an inexcusable lack of consultation and conference with other engineers, traceable to special ordinances born of false civic pride. The first of these disasters led to experiments which have greatly increased our knowledge. The second will lead to a stiffening of the safeguards against inexpert or careless engineering where human lives are involved.

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In asserting the general dependability of engineering, we are far from asserting the perfection of all or any of its achievements. They differ widely in their efficiency as the responsible engineers differ in ability. But it is rarely indeed that the product of the recognized engineer does not *work*. From this standpoint it is a far cry to the latest theories, experiments, and deductions of such sciences as psychology, biology, and sociology. There are no such differences of opinion among engineers as among the experts in these other subjects. The engineer asks questions of Nature and she answers with an indubitable "yes" or "no." To these others she answers as yet faintly, or in Delphic, equivocal terms. Fascinating and limitless have been the projects offered a perplexed civilization by these youthful sciences, but a wise choice will lean rather on the narrower but more certain promises of the engineer. Not that he has a greater or more subtle intelligence than these others — rather, he is more pig headed. *He refuses to deal with anything unless he has proved that it will work.*

A second resource which engineering offers to mankind is *abounding plenty*. For much less expenditure of physical and nervous energy than he is now putting forth, it offers the common man far more of goods, in the way of food, shelter, garments, travel, books — material satisfactions of all kinds — than he has ever hoped to have. This does not depend on some future engineering development — it is within reach now. Present mechanical and engineering processes are producing an unparalleled flow of goods, with a surprisingly small fraction of the population engaged in the work really necessary to their production and distribution. The miner, the farmer, the workman, the engineer, the manager, the railroad, steamship and autotruck operators, the necessary minimum of storekeepers and salesmen — these form but a part of the buzzing swarm in the industrial hive. Take the telephone book in any large city, or make the rounds of the office directories in the vestibules of their skyscrapers. What an appalling mass of subsidiary activities is there revealed! The lawyers, the advertising men, the brokers, the vast sales organizations, the holding companies — and so on without end. Not a man of them but believes in his usefulness and can make out a good case for himself if you will listen to him sympathetically. It is only when we look at this thing in the large instead of in detail that we see the absurdity of the whole affair. Engineering has so tremendously multiplied the effectiveness of the individual workman that material plenty with moderate toil becomes possible for the first time in human history; and thereupon the perverse human being so complicates the process of distributing the manufactured goods that the individual man works as hard as ever and does not get such a tremendous lot more.

Think what could be done, with the ineffectives and supernumeraries turned into workers. There are customers ready for the products of their prospective activities. Look out from the car windows. Observe the isolated farms of New England, the dreary monotony of the back counties of Arkansas, the grimey meagreness of the marginal dry farm in the Far West. Not alone in Europe, Africa, and the islands of the sea lie our future markets. When these economic frontiers of our own land are brought into the magic circle we may experience a height and breadth of material well-being here in America that will surpass the imagination. As engineers we have built the foundations for this prosperity; as citizens we must assist in the erection of the structure itself.

No students of our times have more carefully studied this question than Messrs. Foster and Catchings.[1] Their general view-point and suggested programme are sane and constructive. One gets the impression from their books, however, of a vast and necessary intricacy in the financial and economic phases of the problem, and of a small margin of safety to work with in applying the proposed remedies. On this matter of the available margin, at least, the engineers, from their professional knowledge and experience, can confidently reassure them.

There can be plenty for all. There can be more for all with less than the minimum work needed to keep a man in good mental and physical condition. Take courage, Messrs. Foster and Catchings, and tell us, not how painfully and precariously to stave off imminent and well-nigh inevitable disaster, but how to direct and distribute the flood of goods that engineering skill can make available.

[1] See "The Road to Plenty," and their numerous articles in periodicals.

As a corollary to the resource of plenty, engineering offers the gift of *leisure*. It is a gift that is unappreciated and unaccepted. With the proper persons doing the proper work by modern engineering methods, the plenty which has been offered mankind can be produced in a working week far shorter than any which has been seriously considered hitherto. When the "five day week" is mentioned, most of us who are manufacturers receive an automatic reflex motor impulse from the spinal ganglia which disturbs the circulation of the blood, strangles the speech, and inhibits the free action of the reasoning powers. Perhaps all this can be averted if we avoid the disturbing phrase and discuss the "four day week" instead. For the four day week is an engineering possibility. If all of us do useful work and if distribution is sensibly organized, four days will produce a sufficiency of the necessities and material satisfactions of life. Even three days might conceivably do it. It is all a question of values. As we value goods more and leisure less, we will lengthen our work days. As we value leisure more and goods less, we will shorten them.

We are not now, in fact, prepared for an excess of leisure. Our environment, our education, the air we breath, has unfitted us for its proper use. Reference has already been made to the unnecessary elements in the machinery of production and distribution — the thousands of names which choke the telephone books and office directories. But perhaps it is a wise provision of Nature that as they have been squeezed out of the productive machine by its increased efficiency, these individuals have found employment in white-collar activities. Leisure would be a curse to them as to any of us until we are prepared for it.

Leisure is possible, leisure is desirable. But only a serious educative preparation and the concurrent development of the deeper satisfactions of life by the individual, will ever give it real value in our times and environment.

III

THE NEW age, then, offers tools of proved effectiveness in its somewhat narrow field — the satisfaction of material wants. It offers plenty to all. In addition it offers leisure for the cultivation of satisfactions which are above the strictly material plane. What programme can be devised for making these resources available?

There is no intention in this chapter of making detailed suggestions. That is the province of the specialists who follow. A few general suggestions only may be given here.

In the first place, there must be some general agreement as to the ends desired, if we are to obtain the co-operative action necessary to their attainment. There is no sense in stopping short of the highest goal on which we can reach a community of thought. There has perhaps been no better expression of man's sense of the deepest values of life than the time-honored trinity of Goodness, Truth, and Beauty. Men of the same period, culture, and locality will probably come more nearly to a general agreement as to human welfare in endeavoring to give concrete expression to these values than in any other way. We must lose our self-consciousness, our uneasy sense of hypocrisy, in pronouncing these words. They must become the commonplaces of our thought and action.

This view-point must become a matter of formal education. In particular it must enter into the education of the technical student. Mr. Pendred, editor of the *Engineer* (London), has recently written:

> The murmuring will grow in volume, the protests against the obviously objectionable features of engineering will become louder and louder — we hope they will — and the benefits which the works of the engineer confer will be overshadowed by the nuisances that accompany them, unless — unless engineers themselves are the first to recognize the defects and the first and most eager to remove them. We must not say, if you want railways and motor cars, you must put up with the noise; if you want steel and coal, you must sacrifice a whole countryside to filth and ugliness; if you want cheap electricity, you must poison with ashes and sulphur the air of your cities. That was the attitude of the past; it will be intolerable in the near future. We must have the products which the engineer, and the engineer alone, can give, but they must be so purified from all offense that they can live side by side with less material, but perhaps not less important cravings of civilized people. It is of importance that the coming engineers should have the defects kept ever before them, and that they

should be taught that the greatest aim that they can have is so to discharge all offense from engineering that not the keenest critic can find a word to say against it.

We are convinced that to the engineer all things are possible. He can give us a pure atmosphere and noiseless streets, he can remove slums and make wholesome factories, he can wipe away degrading occupations and improve the occupations of leisure, he can make a fair country out of a blasted waste, and clean rivers out of foul ditches. All these things, and a thousand more, he can do without robbing us of a single one of the benefits and advantages which his works confer. We say this with confidence, because we witness daily all that he has achieved. But a vast amount remains to be done, a mountain of ugliness remains to be removed, and we deem it a good thing that the coming generation of engineers should grow up in the belief that it is the duty of engineers to make the countries in which they live more beautiful and more pleasant and wholly free from the taunts which artists, literary men, and philosophers may justly throw at them today.

This change in view-point of the engineer alone, however, will not suffice. There must be a reciprocal desire in the heart of the capitalist who accumulates the funds, or at least an irresistible and implacable public sentiment which enforces these ideals upon him.

The case of the capitalist is indeed far from hopeless. Responsibility for humane policies and æsthetic treatment in industrial enterprises is being felt more strongly — not less. As a matter of fact, the effective pressure of conscience in our day is directed more strongly toward the business and industrial relations of the week days than toward purely formal morality, or toward specific religious observances on the seventh day. To many this may seem regrettable, but it makes for the consummation we have at heart.

In the early days of industrialism there was a complete callousness as to the means by which wealth was amassed and a purely perfunctory distribution of a portion of it in unconsidered "charity" was a satisfactory discharge of the social obligations incurred. In our time we have seen a decided advance both in the methods of accumulation and of benevolent spending. There are innumerable things which the ordinary intelligent and conscientious business man will not do in amassing wealth; and, in addition, an incredible amount of clear-headed painstaking thought has gone into its use for general social betterment after accumulation.

There remains a step, not generally taken as yet, but seen more and more clearly, and plainly indicated by the course of events. There is now demanded an integral organic benevolence. The principal concern of the capitalist of the immediate future must be to so order his affairs that *the very earning of his money will be in itself a social service,* irrespective of the use he later makes of it. So far as our present vision goes, the highest social service the individual can render is to engage in the manufacture and distribution of goods which are useful, or beautiful, or both; and so to do this as to give secure, remunerative employment to the largest possible number of people, under working conditions which give full opportunity to ability, and likewise satisfy the requirements of human dignity and self-respect. Much of this is under way, but only in scattered detail. Much of our output is neither useful nor beautiful; insecurity of employment is the haunting spectre in the workingman's vision of the future; human dignity is so seldom conserved — and so on.

A re-orientation of our morality toward such an end would be ridiculous in a society which balanced on the verge of bare subsistence. It is only made possible by the wide margin of profit and high operating efficiencies which the engineer can provide. It is beyond the reach of the business which is inefficient, carelessly managed, or insufficiently capitalized. The industrialist and engineer of the near future, working together, are going to derive higher satisfactions and more durable and far-reaching human values from the work itself than they were ever able to purchase over the counter with the lifeless monetary profits of that work.

Thus far, in indicating the desirable developments for the near future, we have explored the possibilities of an organic Goodness, supported by an engineering Truth which keeps its feet solidly planted on the ground. Dare an engineer and industrialist discuss so intangible, so bodiless a thing as Beauty?

Why not? The poet and the artist have not hesitated to discuss industrialism. The industrialist is no further afield in thinking and writing of Beauty.

The writer feels safe in saying that most attempts of artists to give expression to our age seem crude, ridiculous, uncomprehending, and insincere. They are the products of an unsympathetic passerby who sees but does not comprehend. These endeavors to give expression to modern life are the products of rank outsiders, and instead of performing the avowed function of interpretation, they falsify instead.

There seem to be two courses open to us in the search for Beauty. On the one hand there is the development of an understanding of the great art forms of the past, and the careful and sympathetic adaptation of those forms to our own life, wherever this can skilfully and appropriately be done. Yet the possibilities of such a course are limited in that they are imitative and not creative.

The other course is the search for fitness of line, mass, and coloring, based on structure and use. Let us avoid top-lofty words. Let us call this "fitness" not beauty. The fitness of the racing yacht; of the bow and superstructure of the *Bremen;* of the New York Telephone Building; of a Cincinnati Milling Machine; of the stream line body of the Renault "Monosix"; of the sturdy self-respecting splendor of the *Kungsholm* (*à bas* the *Île de France* with its neurotic feminism); of an airplane; of the sleek electric train, gliding serpent-like up the grade to the St. Gothard; of the Philadelphia-Camden bridge; of the apparatus of the modern bathroom. All this fitness is of the integral, organic sort in which the engineering sense is the determining factor, whether designed by the engineer, or by the despised "commercial" artist inbred with the modern world, or by that rarer phenomenon, the real artist with the new vision.

The gift of leisure which engineering offers holds possibilities for real beauty also. There must be, here and there, men and women who will do routine work faithfully and gladly, for the sake of unencumbered hours with the arts. The plenty which engineering can provide offers support for the revival of craftsmanship as well, under conditions which permit dignified support and assured position to the craftsman. This consummation becomes possible as wealth is accumulated in individual, corporate, or public hands.

We may, indeed, descry the approach of an æsthetic dualism.

There will be a place for the monolithic cement structure and for the hand-laid masonry wall with its fascinating texture. The New Age will accept the flood of low-priced, standardized machine-made goods for the sake of the human value of wide-spread necessities and comforts; it will demand, however, that these goods be structurally and materially honest and that they have this *fitness* of line, form, and color. On the other hand the New Age will provide the resources for the study of beauty, for the understanding of what has been wrought in former ages, and for the making of a beauty that is truly modern. The craftsman's skill and the artist's daring may come to exist more richly and fully in this world of more abundant resources and more general freedom.

So we may awaken some morning to find that we have made the great synthesis — have joined usefulness and beauty and the character of our daily activities into one organic structure — have once more made Art and Life one and indivisible. Here lies our way, rather than in obstinate and self-conscious plungings into the morass of the primitive and decadent.

IV

WE LIVE indeed in dangerous times. The earlier civilizations did not survive their coming-of-age. In their youth they were safe, for their social structures were formed of customs, religious observances, taboos, and what-not, which, though ridiculous in details, yet contained elements of true survival value generated by the slow process of evolution. It was a sound instinct which led the Greeks to distrust Socrates and Euripides. In a real sense the profound intellects of Athens' greatest period, in examining the traditional values critically and rationally, thereby destroyed the Classic culture. Our age is a strictly homologous one and there is danger that we too may empty out the baby with the bath.

By blessed chance, however, the critical forces are not the only ones at work with us. The beginnings of wide-spread and deep-seated constructive forces are appearing as well — self-conscious, rational formulas to replace the unself-conscious *mores* derived from animal evolution.

This New Morality for the New Age is as yet a large and cloudy affair, but with certain characteristics already condensing into distinctness. Some of them have already been touched upon — its aspiration toward sincerity in form and its tenderness of conscience toward secular rather than toward sacred activities.

Another outstanding character is its cheerful optimism, based on the epochal discovery that, in the engineering age, normal business relationships may result in advantage to all parties concerned. This is real good news — a veritable Gospel. It has its apostles also — drawn as might be expected from the mass of humanity rather than from the intellectually élite. Not many wise, not many mighty are called. It is the derided Rotarian who has caught the vision of the unity of service and profit. Only for us of this age, provided with the necessary machinery and organization, has it become fully, plainly and overwhelmingly true that the great material rewards come from co-operation rather than from plunder and exploitation.

This discovery relegates to the secondary rank the morality of frustration, pain, and self-sacrifice. So long as mankind was the plaything of material and social forces too complicated for it to cope with, so long was this morality of submission and compensation necessary. With our new-born success in adapting ourselves to the laws of nature these virtues lose their importance, being applicable only to the diminishing field of our ignorance and failure in the practical realm.

From the increasing success of our adaptation to nature there becomes possible for us a whole new ethos of accepted responsibility and of unclouded achievement. The new atmosphere is full of promise and deep satisfaction. Yet it holds no automatic blessings, everything must be searched out and worked for. Nor above all does it minister to human conceit and vainglory, for man has merely submitted to and come to terms with Nature — he has not conquered her; he has even discovered that he can never hope completely to understand her!

In the general and undetailed presentations of this introductory chapter, a certain order can perhaps be vaguely discerned as developing in the flux of things. Some of its outlines may be clearly traced; other features are lost in the mist. Will this new order prove to be more satisfying to the human soul than did the old one? Will it completely please us all? Probably not.

Artists and philosophers are almost certain to pine for what is not, to find in the new strength and beauty and abundance certain definite limitations. They may miss the graceful, gracious, sophisticated style of living by a small and favored class which has characterized such periods as the eighteenth century. Perhaps we cannot today surpass the intellectual keenness, the social polish, the æsthetic sensibility of that period. We find it preserved for our own wonder and admiration in such charming repositories as Kensington Palace, close to the heart of modern London. The grace, the fine finish of that vanished world owed not the slightest debt to engineering and industrialism. It was destroyed by them.

Shall we, therefore, condemn and repel these barbaric invaders of the old culture? Read the wise words of Violet Markham, writing of another time and another race, but of the same problem.

> This Gallo-Roman society of the fifth century has a curious parallel in another age. Across the centuries generations touch; the wealth, the culture, the fine country houses, the sense of public duty, the total disregard of the poor and humble, save as objects of pity and patronage — this whole outlook on life links the English nobleman of the eighteenth century with the Gallo-Roman patrician of the fifth. Both had qualities as well as faults; both left a mark on the civilization of their age, without which the sum total of certain things might have been poorer. But the world, as constituted today, has other values of excellence than that of cultured idleness. It views, with an eye increasingly hostile, the irresponsible possession of wealth, and, as we turn the pages of the fifth as of the eighteenth century, we feel that, apart from the superficial amenities and the fine life of the few, the difficult world in which we live today rests on a sounder basis and aims at better ideals.[2]

On the other hand, the modern need concede little or nothing to such an age. The power to produce its glittering material shell is ours a thousandfold. The ability to recapture its exquisite rhythms of wit and manner is mostly a matter of desire. As a society we shall never sigh for it. And the new and particular activities of the mind and spirit which we may evolve are the vital matters for our impulses and abilities. They will be our own. As such they cannot be our ancestors'. Yet let us hope that eventually the new culture will shine with a light sufficiently bright and firm to make us willingly forego those which have preceded it.

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[2] She has been reviewing the letters of Sidonius Appolonius. The passage is to be found on page 253 of her "Romanesque France."

After all is said, this complex continuum of human existence has resisted hitherto all rational analysis of its inner structure. The great cultural waves which sweep through it come from the great deep, and to the great deep they go. The tool of reason has given us a limited but effective control over their material manifestations. Beyond this we can with some confidence descry the movements and directions of the deeper currents a little before their disturbing power bears down upon us. More, we cannot do. Let us beware of expending our energy completely in a struggle with forces which we have not yet learned to understand and manipulate — let us rather, and in the constructive sense, join Candide and "cultivate our garden."

Furthermore, let us maintain an objective attitude toward life, and let this henceforth be the main direction of education. Experience with "the modern temper" in the brightest of the young men and women of our time leads us to question how much there is to hope for in the purely *personal* experiences. The course of individual experience has been charted for generations. Our hopes, illusions, fleeting gratifications, and ultimate despairs are the theme of a limitless and authentic literature. This literature is reckoned to be the highest achievement of the human intellect to date, and is thus the principal educational material used on the superior youths of our time. As a result they go forth into life with the bloom rubbed off and the curtain lifted from its mysteries long before they have been personally experienced. Nor is this condition necessarily undesirable. But it is the immediate cause of the irony and ennui which are rampant in the couchant mass of our young intellectuals.

For them the remedy is obvious. As compared with their personal cycle, the varying and successive elements of the cultural cycle are on a vast scale and full of interest. The very recognition of them and of the nature of their relationships is new. Here are variety and novelty. Here flows an onrushing tidal sweep which will not reach its flood in the time of any individual now living. To point the view of the youth out and not in, and to set him, in this mighty manœuvre, the objective task of adapting the material world to man's deepest satisfactions — all this will insure a usefulness and a mental health of which the more highly educated among them had begun to despair.

We cannot retrace our path along the cultural cycle if we would. The nostalgia for antique simpler days may burn within us, but Time's arrow points ever forward. Mankind fulfils its destiny in its advance, step by step, into new difficulties, new experiences, new accommodations to new environment.

We would not have it otherwise.

II — SCIENCE LIGHTS THE TORCH

By ROBERT A. MILLIKAN

A HUNDRED THOUSAND years ago, or it may have been that number multiplied either by five or by a fifth, perhaps in China, as per Charles Lamb's whimsical tale, perhaps somewhere else, for no one knows either where nor when, roast pig was discovered — otherwise stated, *a use was found for fire*, and in the moment of that discovery the age of the brute was gone and the age of man was born. For no savage has ever been found so low as to be entirely wanting in that knowledge, and no mere brute possesses even a trace of it. No wonder the poetic Greek wove the event into a beautiful heroic myth; no wonder that ever since then Prometheus's act of stealing fire for man from the chariot of the sun has symbolized the eternal quest of the spirit of man for knowledge, and no wonder that in world history fire worship has been the centre of more than one great religion.

The multiplying uses of fire seem during all time to have been a fairly sure index of the progress of civilization. As man successively used fire to signal to his tribe, to warm his body, to cook his food, to glaze his earthenware, to synthesize his bronze, to refine his gold, to extract his iron from its ore, and to temper his steel, he rose step by step from the state of the cave dweller to the state of the citizen of Athens or of Rome; and now, within the memory of men now living, the crowning step of all has been taken, a new use for fire has been found, a use which makes it the keystone in the arch of modern civilization and opens up glorious possibilities for the further age-long progress of mankind. Whether those possibilities are to be realized or not depends in large measure upon what the scientist and the engineer henceforth do with fire!

In classic times there were just four fundamental independent and more or less co-ordinate entities: Earth, Fire, Air, and Water. Only about seventy-five years ago when Joule had experimentally established the equivalence of heat and work, and the Principle of Conservation of Energy was struggling to break its shell, fire lost that independent position but at the same time it began to form a trust and to amalgamate with its neighbors. Since modern science has developed no trust-busting propensities of any sort, the fire trust has grown in power and influence until, a very few years ago, Einstein reorganized the whole physical world under the hegemony of fire. Earth, air, and water, indeed all forms of matter, are supposed by him to be leaping continuously of their own accord into the furnaces of the sun to keep the great fire-ball going, and this sacrificial act on their part is alone responsible, according to modern astronomy, for the fact that we are here today. Otherwise we should have been long ago merely the ashes of a spent star system. The job of the physical scientist and the mechanical engineer becomes henceforth, then, simply this — *to see to it that that radiant heat thus produced and thus coming to us from the sun is utilized to the fullest possible extent to make this world a better one for man to live in, in the future, than it has ever been in the past.* The sign-posts that man has left behind him in his progress upward indicate clearly the way in which this is to be done, and I am taking it as my chief task herewith to try to read these sign-posts.

I

My first reading has to do with the mere direction and shape of the curve of history itself, my second with the method that seems to have been used in drawing that upward curve, my third with the identification of its draftsmen, and my fourth with what seem to be our own opportunities and responsibilities as scientists and engineers in connection with it.

Taken in its total sweep, the curve of evolutionary history obviously shows no place where pessimism can normally find lodgment and hold on. From amœba up to man is certainly an inspiring record, and from caveman up to Einstein one even more so. Hence the prophets of disaster among us must perforce look at the curve microscopically instead of macroscopically and point out that it has had its ups and downs, and then emphasize the downs and project them into the future in order to have any case at all. They struggle hard to find periodicities, cycles in these fluctuations, and then proceed to predict on the basis of these cycles "The Decay of Western Civilization." Spenglers and Kaiserlings don Cassandra's skirts and shriek loudly for an audience — not at all difficult to get since the advent of a press that is avid for sensations and a public taste that hankers for extremes.

But in point of fact the ups and downs of history have certainly been too few to warrant any valid statistical cyclic generalizations, and besides the conditions in the past that permitted periods of decline to occur have been so changed by the modern multiplication of agencies for both the spread and the preservation of science and of art that if there is anything that is certain it is that the Cassandras of the present merely represent a class that has always existed at all times and in all places, the class that in the language of Job "multiplies words without knowledge."

It is altogether obvious that no man can predict with certainty the future, but it is at least unlikely that the curve of evolutionary development that has been moving, on the average, steadily upward for millions of years is just now in process of turning over and moving downward. Furthermore, there is abundant historic reason to expect that man, with his rapidly increasing control over his environment, will be able to stabilize somewhat his own curve in the future so as to prevent at least some of the fluctuations born of panic and ignorance that it has shown heretofore.

II

So MUCH for prediction from the curve itself. But let us now look deeper and try to discern some, at least, of the causes of the upward movement and the agencies employed. And here I wish to paint a picture which stretches through many ages.

It is first a picture of primitive man using his campfire to guide his steps back home when darkness overtook him; warming his hands and feet before it on frosty nights; accidentally, I suspect, discovering that his food tasted better cooked than raw; merely happening, no doubt, some time to build it very hot where liquid streams of metal ran forth from ores; then curiously mixing these molten metals till the age of bronze appeared, and then the age of iron and steel.

All this is the method of pure empiricism — call it engineering if you will — lasting many tens of thousands of years and portraying the situation so far as man's understanding of fire is concerned up to a hundred and fifty years ago. But why had none of these millions upon millions of men who had sat before the campfire or the grate and felt its genial warmth never guessed at all the secret of fire, never dreamed at all what heat was, namely, *energy which could be made to do their work for them?* The answer is obvious. *It is simply because the method of empiricism can go a certain distance and no farther,* because such guessing as I have just suggested unquestionably requires a background which none of these millions of men sitting before the fire possessed, because it requires a group of concepts which had never entered their minds. Even the very word energy had never yet been used up to their times to denote a definite measurable physical quantity. It appeared in the English language in that sense only about seventy-five years ago. No understanding of heat was possible before the principle of the equivalence of heat and work had been demonstrated and the principle of the conservation of energy had been formulated. No caveman, no Tutankamen, no Pericles, no Cicero, no Galileo could think about *the kinetic energy of a molecule* because the concept of kinetic energy was unborn, and it could not be born in the era of pure empiricism, for it is an analytic concept involving the integral, or work function, $\int fds$, and no such concept had been formulated until quite recent times. Do you know that when Helmholtz in one of his historic papers (1847) was struggling toward the formulation of the energy principle he entitled his paper "Die Erhaltung der Kraft" (the conservation of force), thus mixing up two concepts, force and energy, which are completely different things, and which no high-school pupil would today be allowed to confuse without suffering a penalty?

I am trying to present herewith the bond between pure physics and engineering. That bond is obvious from the foregoing facts. It is the bond between the parent and its child. Mechanical engineering is, broadly speaking, the practical knowledge of the use of energy-transforming machines, or, as we call them, *power machines.* No such knowledge existed until it was borrowed from the pure sciences, astronomy, mathematics, and physics, during the last quarter of the eighteenth century and the first three-quarters of the nineteenth.

But how did these sciences have that knowledge to lend? It is one of the most inspiring stories in the history of the world, and it chronicles as important a series of events as has ever taken place. It is the series of events which makes the future bright with hope, not only for the scientist and the engineer but for the race itself, for *it is the story of the discovery of the method of present, and, presumably, of future progress.*

The method was worked out wholly from the standpoint of pure science, for it was before the days of applications. It was worked out by men who were actuated simply by the desire to know, men who were looked upon by their times as mere scholars, dilettantes, dreamers. Now that science has proved its utility it is pursued as a practical, utilitarian calling by large groups of men like those represented in the engineering societies. The more glory to the men of the sixteenth and seventeenth centuries, who laid its foundations merely because they believed in the value of knowledge to the race. And it will be a sorry day for the race, too, if their kind should ever disappear. Let us do our part to see that the sacred fire does not burn out. For when it goes, if ever, then the springs of human progress will have disappeared.

Here is, then, the story that made the story of fire that I am telling a possibility — the story to which that of fire is but the necessary corollary. Through all the ages of savagery and ancient civilizations men had pushed carts and pulled wagons — exerted forces and observed motions, but why should they worry their heads about the exact relations between the two? Why should they try to define work when they knew well enough what it was to be tired? And they did not try to do so. Nobody among the thousands of millions of people who preceded Galileo ever knew what work was — and, *sotto voce,* some of us don't know yet. None of them ever did more than guess, and guess wrongly, too, as to the laws of force and motion. But Galileo spent a lifetime in working them out exactly and in proving that force is measured by mass times acceleration. Without his work Newton could not possibly have discovered the law of gravitation, and without their joint work seventeenth- and eighteenth-century developments in mathematics and in celestial mechanics — the purest of pure science — culminating in La Place's matchless *mechanique celeste* — could never have seen the light. All this was simply laying the necessary foundations for the application of the laws of force and motion to the power machines that began to come along toward the close of the eighteenth century. The concept of work as the product of force and distance had by that time been born, the integral $\int fds$ had a meaning, and the proof that the work done in setting a mass in motion was exactly measured by $\frac{1}{2}mv^2$ had by that time been made. All this prepared the way for the definition of energy as capacity for doing work and made possible the concept of heat as the kinetic energy of molecular motion. *All this was necessary before the idea could arise that fire could be used to do the world's work for it,* could be made to lift the burden from the backs of human slaves. That tells you why men used fire for a hundred thousand years, mayhap, before they thought of what it was or how it might be made to do their work for them. Pure science had to lay the foundations of a correct understanding of Nature before this became possible. And there you have the discovery of the method by which our modern progress had been brought about and by which, too, our future progress is to be made, if it is made at all.

III

But next, who are the agents to whose hands the keys of progress have been entrusted, the draftsmen who are to draw the curve of future progress? The technical job has obviously been assigned to two groups. The first group consists of physical scientists and engineers, the men whose job it is to see that the sun's rays, past and present (for we probably have no other source of energy), are harnessed to the best advantage possible for doing the work that mankind needs to have done. The opportunity here is enormous, though not exactly limitless, since an uncontrolled increase in population can obviously in time exhaust any assignable food supply so that without an intelligent development and maintenance of population the work of the physicist and engineer, however effective, may be rendered unavailing. Here, however, is where the job of the biologist and the educator comes in, and *between these two groups the technical aspects of the whole problem can certainly be solved.* With the spread of knowledge and education made possible through the leisure brought about by transferring the world's drudgery to the back of fire (*i. e.*, to machines), I think we can be certain that an intelligent mankind will find how to keep a proper balance between population and the food supply. England, Scandinavia, and Germany — as intelligent countries as the world possesses today — have quite recently applied this intelligence and reduced largely their birth rates.

IV

But there is another aspect to the problem, namely, the *direction* of the social forces, of the industries, of the large group activities — to whom is this job in the future to be assigned?

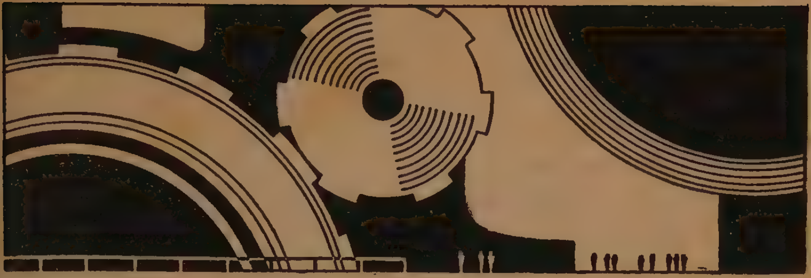
One thing is certain. *No man is fit to do that job who has not had an education that makes him not only fully conversant with the scientific method, but fairly conversant, too, with the foundations of science itself.* I anticipate, therefore, that in the future, as industry itself becomes more and more intricate and complex, the directing minds will be drawn more and more from the group that has had a thorough scientific or an engineering training. I do not see how it can be otherwise, for certainly some understanding of the basis of our civilization, and this is certainly scientific, is needed to enable man to act intelligently in it; and, secondly, there is no education that can compare with the scientific one in thoroughness and analytical rigor, and none which teaches so well the objective method, the world's most supreme need for the solution of all its problems.

Let it not be supposed, however, that I lay all the emphasis upon *material* things. A starving man may, indeed, be both happy and in every way admirable, even sublime, but he can keep it up only till death comes. In other words adequate food and shelter and leisure for intellectual and social development for all are obviously a *sine qua non* to race progress, and science and engineering are today furnishing them as never before, and promise indefinite improvement for the future. Thus, according to statistics published this year by the National Bureau of Economic Research, the period from 1909 to 1927 has seen the income of the average wage earner in the United States rise from $527 to $1205, which, after making due allowance for the increase in cost of living as reflected in the rise of index numbers from 1.00 to 1.50 during that period, gives aforesaid wage earner a 50% increase in real wages since 1909, and this has accompanied a decrease in working hours of from 10% to 20%. Approximately the same figures hold for the salaried employee, whose income has increased from $976 per year in 1909 to $2084 in 1927. These increases in wages are also shown by the same unimpeachable authority to be approximately proportioned to the joint increase in manufactured and agricultural products within that period, thus seeming at least to show that the way to increase the working man's return is to increase his productivity, and that is precisely what science and its application in engineering have been doing so conspicuously during these past two decades.

Also, until the stored-up energy in coal and oil is all spent the world's economic problem is to conserve them and get every possible foot pound out of them. This is the problem solely of the scientist and the engineer, and they are jointly pushing up each year the fraction of fuel energy utilized instead of wasted.

When a thousand years hence the oil and coal are gone, it will be the scientist and the engineer who will capture with a solar engine of some kind the sun's fire and do man's work with it. We need not fear the exhaustion of our stored supply, for two modern counties receive in a day as much heat as is produced by all the coal burned in twenty-four hours throughout the world.

But when all this is done, the job of decent living is only just begun. What man will do with his leisure and his new-found powers is not our job as scientists and engineers, but it is our job as citizens, and it is my conviction that the training in *the objective method*, which science and engineering furnish, if coupled with the adequate understanding of human values that comes from suitable familiarity with history and literature, constitute the best preparation for life in almost any of its phases that can be obtained today. If my son wanted to be a lawyer, I would give him a scientific education as the best preparation for the law. Society needs knowledge and understanding in its leadership, and increasingly so as it becomes increasingly complex with the growth of new scientific methods and processes. Since the foundation of education is obviously, first a training in the objective method, and, second, a thorough knowledge of the world in which we have to live, I anticipate the increasing social leadership of men well grounded in the fundamentals of science. That is one of our opportunities and our responsibilities as scientists and engineers.



III — THE SPIRIT OF INVENTION IN AN INDUSTRIAL CIVILIZATION

By ELMER A. SPERRY

IF, as alleged by the critics, there are perils of overstandardization in the drift of our mechanical development, there are also powerful counter forces in it. The type of civilization now in the making depends not merely on logic, mathematics, and the nature of physical laws; if it is to advance and improve steadily it will continue to require and promote, as it does now, the imagination, courage, and brooding meditation of the inventive faculty — the venturesome spirit of invention. Indeed the very tempo of industry stimulates and calls forth the exercise of this power. Besides being useful in devising machines it is equally useful in any attack on the evils of our civilization, such as congestion of population, traffic snarls, ugly structures, badly planned cities, and ill-adjusted industrial relations. For these reasons, if for no others, the art and methods of invention cannot possibly be omitted when an attempt is made to strike a balance sheet of the values inherent in our civilization.

The fundamental inventive faculty is so widely distributed in the human race that it may almost be considered as an instinct. Outside of the intellect itself, it is the greatest single trait that differentiates the human race from the animal kingdom. Much better than lies within my capacity, it has been stated that it is the one outstanding factor that has brought the race to its present high state of advancement.

Considering the aboriginal man, we can at once see that with every obstruction in his road invention was called into play in its removal. It is doubtless virtually true that every time the individual was called upon to devise an expedient he was really practising his inventive faculty. He had to imagine how this, that, or the other expedient would serve his purposes best, and this fits almost exactly into our conception of the accepted definition of the inventive act. This trait is not evenly distributed in the race. It has probably been recognized from earliest times that some are not only vastly more skilful than others, but that the perfection of the result and quickness in the achievement have always been directly proportioned to the skill with which the operator in question could employ the imaginative faculty.

This, I feel, cannot be too greatly emphasized, when we think of the utter helplessness of a new-born babe as compared with the offspring in the animal kingdom, which may be said to be able almost universally to shift for itself practically from birth. The chick no sooner emerges from the shell than it starts to pick here and there in a search for food. No wonder mankind has been forced by sheer necessity to use its special and God-given endowment of the mind to make up for its comparatively puny and helpless estate.

As was stated by the late and universally beloved John W. Lieb, early associate of Edison, and distinguished in the constructive application of Edison's system of electrical distribution:

"If we stop to think, we must very soon come to the conclusion that every single feature which characterizes our modern life is based fundamentally on an invention. It seems probable, moreover, that man's very existence, his survival all through the various dark periods of primitive life from the caveman stage upward through the hundreds of thousands of years of continued fighting for his very breath of life, would have been impossible except for inventions. Indeed, without some important inventions, puny, weak man, naked as he was created and utterly defenceless, would not have survived a single generation, surrounded as he was on all sides by a world of fierce and powerful enemies of the animal kingdom. These considerations have given rise to many thoughts on the part which inventions have played in the upward progress of the human race.

"In considering primitive man in his unfriendly environment we see at once that he sorely needed some aid in his defence; he required tools, weapons, and other protective agencies. While animals, too, use weapons to a limited extent, for apes can deliver quite an effective blow with a stick or even throw stones, yet they have never been known to put a handle in a stone hammer and never has an animal been known to light a fire. Indeed, the ability to light a fire may be considered one of the greatest inventions of all times." It is of some interest to reflect that fire, as produced by nature, was observed by primitive man to be always destructive and terrifying, and it required some display of courage to dare its deliberate production and devise methods for its control so that it ministered to his needs.

"Therefore, when we dig deep down in the earth among the undisturbed geological strata and discover a heap of ashes, an axe-shaped flint or stone hammer head, a bone with perforations or rude carvings, we may know that here, ages ago, someone has made or was utilizing an invention; that here had been man." A most interesting example of this is a carving on a reindeer horn which has just been discovered, that authorities date back to 30,000 years B.C.

To follow in this train of thought and develop it from a different standpoint, I can do no better than present here, in abstract, a literal translation from one of Max Eyth's splendid word pictures:

"This pitiful creature (man) was bound to perish, every rational being would have said, if he had had an opportunity to observe him in those days engaged in the struggle for existence. The animals of his days, too, presumably considered him as one of their own and straightway set to work to destroy him. Then, however, a certain something bestirred itself within the little man, something that the world had not witnessed before. He sharpened the stone with which his father had tried in vain to shatter the cave bear's skull, he equipped his club with sharp stones and his stick with a point made of a bone, he made for himself another skin out of the hide of the slain enemy — in each case he made an invention. And then! someone made the greatest progress of those early days: there was invented the kindling of fire. The human race was saved! and from now on man's environment begins to bow in subjugation before him."

We may now seek to define this word "invention," which, as we have seen, furnishes the key to man's ascendancy. Invention during the past century has been defined in many ways and tens of thousands of decisions have been handed down by learned judges, bearing more or less on different aspects of the definition as a whole. This also applies to the many lines of approach to the subject, including the psychology of the one attempting the definition. The very simple definitions are so familiar that I shall not dwell on the subject, but I may state from long experience that I have always been struck by the fact that, apart from vision as an important factor, enthusiasm and persistent effort are always present with the successful inventor. I believe also that he has kept up with the changing times. In the past he was often looked upon as impractical and, as one high authority states, was likely to work years without producing anything. This may have been true years ago, but as time has advanced, if he is at all successful it means that he is not impractical but brings to bear upon his problems all of the facts and traditions and everything that science can teach on the subject, as well as his own experiences and those of the others in his particular field.

Be this as it may, I feel that the old-time inventor should be given the rank to which he is justly entitled. The title itself is one of honor. In talking about inventors with Elihu Thomson about twenty years ago, when they were considered more of the long-haired variety, I was impressed with the fact that he was inclined to dignify this profession or art almost to the point of glorification, and as time goes on I feel that there is much truth in his estimate.

After all, the most prolific producers in the inventive field are those possessed of inquisitive minds combined with vision. They are more likely to be the first to see the light and realize the creative force, because after everything is said and done, there is an elusive something connected with it all that we call genius. We are all familiar with Mr. Edison's definition of genius, in which work is the dominant ingredient, "95% perspiration and 5% inspiration."

I often think that patient, thoughtful and persistent work is about all there is in it. In corroboration of this, I might cite what one great American author has well said on this point, i.e., that "there cannot be any question but that work is the father of genius." We all know that we often surprise ourselves as to what we are enabled to achieve when we are in the midst of a tense struggle, with no end of hard work ahead, but with our eyes on the goal. But why this untiring enthusiasm, this burning imagination, and this persistent urge ? Is not this in part the essence of the spark that we call genius ? This spark, whatever it is, undeniably exists and is universally recognized.

Note what the great research head of the Eastman laboratories in Rochester, working in an abstruse and difficult field of science dealing with light and photography in all its multifarious ramifications, says: "The inventor is a valuable man in any research organization. He finds a path around or across when the research man has been stopped. When you get your hands on an inventor freeze onto him !" And this statement is made with no other purpose in view than to further and aid his laboratory work. I have heard this sentiment expressed by other competent observers and, I feel that it is nothing more or less than a tacit recognition by our highest authorities of this inborn trait which certain individuals possess and which urges them on to exercise their faculties along peculiar lines of endeavor. This would indicate that no amount of organized research will ever serve wholly to eclipse this type. The world's progress owes him much and I feel that we cannot do him too great honor.

In continuing this line of thought, I have never believed that the ordinarily accepted definition of invention has given sufficient emphasis to one element that always must be present to a greater or less extent, namely, Courage. No invention that has furthered the progress of mankind has ever been achieved without the manifestation of courage at some point in the procedure. Of course this element occurs in different degrees, from a point of minor significance to the point where it is almost the controlling factor. Too much emphasis cannot be placed on the fact that sometimes — somewhere — bringing an invention to the stage of making a definite contribution to progress involves courage on the part of more than one worker and often a whole class of workers. Again, the controlling factor in this process is often courage in the financial backing necessary to the development of the idea. The more one considers this phase of the question, the more apparent it becomes that sooner or later in connection with every development that has become useful, courage enters into the operation and sometimes rises to paramount importance.

Let us consider courage in a somewhat broader aspect. Courage is one of the greatest world forces, if not the greatest. It is courage that has marked leadership in all times. The great world advances in all departments, including the arts, have from time immemorial depended on the courage of leaders. True it is that this word has almost always been associated with wars and warriors. Men dream dreams and have visions and we call them visionary. Once in a while some of these have the inquisitive faculty, but their projects still may die in an early stage. In this case the world has not been advanced. However, when one other factor is added, namely, indomitable courage, then the pioneer pushes his way through untold hardship, finds the mountain pass, and is the first to envision the whole new world lying beyond — the sunlit fertile valleys and vast unutilized resources. Thus it is that the inventor achieves and, also, thus it is that in unfolding the secret of any nation's advance Courage is given a much broader significance than is usually conveyed by narrative history.

An advance in the arts seems possible. Research work is undertaken and inventive skill applied, possibly in several widely distributed countries. The object sought is reported as finally having been achieved by one or more of the groups of workers. Much discussion immediately ensues among scientists and technicians, the knowing ones the world over. A decision is reached to the effect that the process is as yet purely experimental and that much work must still be done upon it before it can be considered at all for practical use. The world considers the incident closed and turns to other things. Tradition and dogma have had their innings and have spread their blight. Exactly in the ratio that a country or community is tied down by this conservative spirit and is timid, is it the last to reap the rich rewards of pioneering. It is only the nation or community with courage, which, after continued investigation, decided that the matter has advanced far enough to justify attempts to put it into practice. Pioneers quietly build the initial small unit. Through close observation and by research and invention changes are made and finally a commercial result of great importance is achieved. They then enlarge the plant, increasing its capacity to a marked extent, and build other units still larger in different parts of the country. They may make no inquiries as to what other countries are doing, but the world has gained a definite advance in a demonstrated process of great utility. How has this been accomplished? The answer is through the courage, vision, and indomitable energy of these experimenters.

Following the observations above respecting these downright deterrents to progress and blights on the energies that must necessarily be expended if progress is to go forward, it must be said that emancipation from tradition and dogma cannot be overemphasized. "Conservatism" is simply an effort to gloss over its evils and does not excuse it from any of its iniquities. The study of this trait seems to develop the fact that it is worse in proportion to the length of time during which a country or community has been active in any particular line. The older the community is in a given art, the worse is its so-called conservatism concerning it and the greater is the blight upon this art exerted by its dogma. In fact, dogma all down through the ages has been a damning deterrent and has retarded progress by all of its various contacts. A marked example of this is associated with the religions of the world. More wars have arisen from dogma and tradition than from almost all other causes taken together.

Let us pursue this subject into one of its more favorable aspects. Let us now journey to a country that has just emerged from Orientalism, where western thought has only recently become established. Take, for instance, Japan, which to a certain extent voluntarily turned its back on some of the limitations of its oriental tradition and adopted western thought only about fifty years ago. The rapidity in the progress of the Japanese has been phenomenal. When their marvellous performance in this particular has been written up in time to come, it will be looked upon as nothing short of a miracle. Yet it is contemporaneous with us and we are almost unaware of the marvellous magnitude of its realization. Here we have a nation of up-to-date and efficient scientists, engineers, and technicians that are free from dogma and tradition. They have no elders or grandfathers that arrest their progress and tell them that things cannot be done and it is useless to try this, that or the other method. They have brought forward an endless array of mechanical, engineering, and scientific talent that is nothing less than astonishing. These people go straight to the point. After the most careful and painstaking investigation they make up their minds that a certain result can be obtained. They have no dogma or tradition running against this decision and with marvellous courage they go straight to the mark, and lo and behold the result — in many instances so startling that the attention of the whole world has been drawn to results obtained in no other quarter of the globe. A few cases will illustrate the value of freedom from dogma in science.

Take KS steel conceived by Dr. Honda, a great and extremely skilful metallurgist working at the Sendai University laboratory in Japan. He imagined that steel could be produced which would multiply by many times the magnetic retentivity of the best accepted steels. He had the courage and patience to pursue his investigation, which was financed by his friends and those of the institution in Japan; and he had the satisfaction of realizing his dream and obtaining a finished product, which was turned over to the world and has found many uses in the arts, primarily communication, for magnetos, etc. When two small pieces of this heavy steel are laid parallel, with like poles presented, one will actually overcome gravity through mutual repulsion and be "suspended between heaven and earth" without visible means of support — a very interesting phenomenon.

Take another instance where still greater imaginative insight was brought into play by the Japanese in the matter of high-speed films. The speed of taking pictures, after progressing to a certain point, came up against various limitations. These limitations Japanese scientists sought to overcome, for they believed that if the speed could be carried sufficiently high the interaction and interrelation of certain phenomena could in all probability be revealed to the eye and in that way a great tool of investigation and research could be produced. Minute phenomena could be studied and the subtle difficulties preventing the attainment of higher efficiencies could thus be discovered and eliminated; thus, for instance, the operation of air foils, propeller blades, and many aërodynamic phenomena could receive great impetus. The great government aërodynamic laboratory under Baron Shiba went forward with this investigation and was convinced that practical ways and means could be produced to increase greatly the speed of taking pictures which would prove to give the values stated.

The writer has recently returned from Japan, where he was shown all the details of this device, which is nothing short of marvellous. We were startled two or three years ago when we heard that they had been able to secure 10,000 pictures per second, but with the machine that we were shown late in 1929 they have succeeded in running the capacity up to the rate of no less than 60,000 beautifully clear pictures taken in each second. As a result it was found that with sufficiently high-speed films — sufficiently great numbers of photographs per second — the flow of atmospheric air actually became visible and could be studied.

It has taken courage to develop this machine because as one of its essentials high speeds are involved, far beyond those utilized even in gyroscopic machinery. Peripheral velocities considerably exceeding 80,000 feet per minute are employed and if there is anyone likely to recognize the courage that it takes to design anything with this peripheral speed, it seems safe to say that it is one familiar with high-speed gyros and turbines. But this is only a part of the remarkable courage displayed in this marvellous conception. The single item of the shortness of the total time of exposure gave a challenge that would be considered insurmountable by almost any other class of workers than our Japanese scientists. They were not daunted by the fact that they were already able to obtain an exposure of only .0096 of a second. It certainly took courage to believe that enough would be shown in this brief period of time — less than a hundredth of a second — to be useful.

The Japanese government, furthermore, had the courage to appropriate the large sums necessary to build this two-ton machine and the results are nothing short of marvellous. Dr. F. B. Jewett, the head of probably the largest research laboratory existing in the world, with between 5000 and 6000 research engineers under his direction, states that this instrument is doubtless one of the greatest research tools ever produced, and this comes from Japan which was without engineering and technical tradition. How fortunate it is that Japan is sufficiently removed from both Europe and America, where we allow tradition and dogma to blind our vision and blight our objectives.

So aggravating has this situation become that in many instances our modern inventive leaders have been compelled to clear out and actually discharge the older heads when about to undertake specialized technical activities in which they propose to introduce new methods.

When Mr. Ford started to think of going into the flax business he said to his chief engineers, "You have a bright young man in your drafting-room or among your engineers. Won't you bring him in to me?" This young man came. He was almost trembling before Mr. Ford. The latter turned to him suddenly and said, "Young man, what do you know about flax?" And when he replied that he was afraid he did not know anything about it, Mr. Ford said, "You're just the man we want."

Mr. Kettering, President of the General Motors Research Corporation, with his characteristic drollness, recently made the following statement covering this point:

"This is a place where we are supposed to do things. Experts are people who are paid to tell you what you cannot do. Occasionally the experts are called in here. We want to do something that has never been done before. So we have a conference with the experts, if you please. The experts sit around and we tell them what we want to do. Then they all look at one another and at us and smile and tell us that, of course, the thing cannot possibly be done. That breaks up the conference, which is a good thing. Then we go ahead and do the thing that cannot be done. And yet we have been told to look to the older ones for our advice. If we do so, we are listening to a few survivors who, in turn, are listening to a still smaller number who have actually passed on and never heard of the problems which we are grappling with today. These old fellows know more than the young ones. That's the trouble with them — because one of the peculiarities about the things that we know is that so much of it isn't so."

We now turn to another phase, viz., the struggles of the early well-known inventors whose estate is often characterized as being that of "a garret and a crust of bread." The early struggles of many of the leading inventors in the past century, those who have produced some of our most useful devices and mechanisms, have been the basis of many a romance; volumes have been written regarding them. In a hasty review of the most outstanding it may be said that this aspect is almost universal.

Witness the early struggles in departing from the time-honored hand loom of ancient times and coming down to the more modern power loom. Not only were difficulties encountered in finding tools that were adequate for accomplishing the alterations, but there were long struggles in the face of two adverse conditions: first, the physical difficulty of taking the advance step and second, the innovation-resisting experts and public. The latter usually extends to include the most intimate associates of the inventor as well as the industrialist who eventually adopts the improvement. All innovation must necessarily run contrary to dogma and tradition and there is no question but that these two factors are among the worst enemies of progress. Supposed "authorities," necessarily respected and held in high esteem by the inventor, not only denounce the invention but show dogmatically in myriad ways why it is abortive, useless, and unnecessary, and constitutes work in the wrong direction. Besides this, the reason for the innovation is asserted to be purely imaginative on the part of the inventor, who is usually characterized as an idle dreamer. Too much emphasis cannot be given to the fatal and destructive aspects of tradition and dogma. They are like the poor, they are ever with us, and so persistent and insidious are they in their many manifestations that progress is practically blighted.

One of the most original workers in the development of inventions of the greatest possible utility, Michael Faraday, once said that of all his God-given faculties he felt that imagination was his most precious heritage. His work lay on the border line between discovery and invention. He had to devise and invent many mechanisms with which to make manifest his discovery of certain fundamental laws of nature. He was an original worker in pure physics. With the devices that he had invented and constructed with his own hands he made the most profound discovery of the ages, the true correlation between motion, magnetism, and electricity. General J. J. Carty is an authority for saying several years ago that as a result of this discovery alone probably more than ninety billions of invested capital has come to be actively employed.

Then there is the whole category of inventors working on the sewing-machine, including Elias Howe, who finally put the eye in the point of the needle and solved a most important problem. As stated, there is so much romance surrounding these characters that they have made a very material contribution to literature in all modern nations.

Coming down to our own time, we all know the story of A. Graham Bell, with his great heart devoted to the improvement of the conditions of the deaf. He finally developed the electromagnetic telephone, only to open a new chapter of fruitless effort towards its adoption. It was well known that this was actually derided and was thought to have very little promise at the beginning, but finally Mr. Edison's invention of his carbon microphone aided materially in the technical perfection of the instrument. Of course Emile Berliner with his variable pressure contact did work that may have had more or less significance in connexion with this whole art.

With reference to these earlier workers who were poor and struggled for an existence, without the aid of adequate facilities, it is scarcely necessary to recite dramatic passages from their careers. Their lives and labors are now recognized, even in general histories; warriors and statesmen have been compelled to move over and make room for these benefactors of mankind — these almost single-handed workers in the early days of science and machinery.

ALTHOUGH there are still and always will be, abundant opportunities for the old type of individual research and speculation, modern methods so far as they are organized have turned toward the research laboratory, where large aggregations of experts, so called, are concentrated on both general and specific problems. This modern method is coming very rapidly into vogue and taking the place of the old-time inventor who worked by himself or with a few assistants, spasmodically, as he could get time to devote to his problem or get money enough together to take the next step. In any event even his methods were a thumb-nail edition of the modern research laboratory.

It has been a long-hoped-for objective that our research laboratories may make a revolution by freeing us from dependence upon unaided and accidental genius and give genius a chance to unfold with the greatest efficiency. This may eventually be attained, but whatever may be said and done with regard to the research laboratories and the engineers employed therein, there is much evidence indicating that the desired point has not been reached. Dr. Whitney, who may almost be considered the Nestor of us all in heading up large research groups, stated in his paper before the World Engineering Congress in Tokyo in 1929 that the word "research," and especially industrial research, is considerably overdone and is likely to be misunderstood. It is also overdone in many institutions of learning. Nevertheless, it is a striking phase of the modern quest for new and more efficient ways of getting work done, and any discussion of invention must take into account the wide range of research activities now maintained in all great manufacturing nations.

In the United States, industrial research is being carried out in approximately 1000 organizations. These include: (1) government bureaus, (2) educational institutions supported by endowments, (3) trade associations, (4) special groups in an industry co-operating on a special research job, (5) private laboratories maintained by individual manufacturing companies, (6) commercial laboratories which may be called into consultation for special work. A reliable estimate places the annual expenditure for such research at $200,000,000.

The largest private research institution in the United States is the Bell Telephone Laboratories in New York City. Here about 5000 persons are employed and $15,000,000 expended annually. Other large laboratories are the General Electric Company's Laboratory, the General Motors Research Laboratories, and those of the N. I. DuPont de Nemours Company and of the Aluminum Company of America.

The two federal bureaus engaged most extensively in research are the United States Bureau of Standards and the United States Bureau of Mines, each with a grant of from two to three million dollars annually.

Among the Land Grant Colleges the work in engineering research was supported by an expenditure of more than half a million dollars in 1928–29. The staffs engaged in this work consist of nearly 300 full-time workers, with twice that number on a part-time basis. Among these institutions the names of University of Illinois, Purdue University, University of Michigan are well known in research.

There are five large foundations supporting research in the United States: The Rockefeller Foundation, Carnegie Institution, National Research Council, Mellon Institute, and Engineering Foundation.

A recent survey of trade associations shows that approximately ninety are concentrating on research. A total of $15,000,000 annually is spent by less than half of these associations.

In Germany, which first showed the world the value of organized research, control through financial report is centred in the Prussian Ministry for Science and Arts. This office is charged with the administration, co-ordination, and supervision of research. Among the bureaus operated by it are the Physikalische Technische Reichsanstalt, and the Staatliches Materialprüfungsamt. The technical colleges such as those of Charlottenberg and Darmstadt are also productive in research. The central organization for industrial research is the Kaiser Wilhelm Gesellschaft, governing body of the Kaiser Wilhelm Institüt, under which there are forty laboratories. The electrical firm of Siemens and Halske is the most representative private research laboratory, with an annual budget of $100,000; and the Badische Anilin Fabrik is developing the dye industry. It is reported that the Germans spent more than $5,000,000 and devoted twenty years of effort before a single pound of dyestuffs was sold.

In Great Britain the outstanding government bureau in research is the National Physical Laboratory with an annual budget of $800,000. The General Electric Company maintains a research laboratory at an expense of $200,000, while the Anglo-Persian Oil Company operates on an annual budget of $100,000. In the metal industries, the Brown-Firth Company maintains a laboratory at Sheffield and has connection with the laboratory of the University of Sheffield.

These research institutions are all quite well known to students of the subject, but little is heard in the West about the enormous growth of research laboratories in Japan. When I was there seven years ago there were very few. I visited the most important one, which was really quite impressive, considering the late date that the idea had taken root in the Japanese mind. The curve indicating the progress of this oriental empire from the start, only a little more than forty years before that time, had been so phenomenally steep that I had expected on my later visit to discover that there was a knee in this curve and that it had flowed off more naturally, comparable with the curve indicating our own progress, which in itself doubtless compares favorably with anything on the other side of the Atlantic.

To my amazement, however, I saw no evidence that the break had come or was even in sight. The curve was going on with the same steep gradient that it had seven years ago and the reason for the continuation of this marvellous progress was not far to seek. Now we find that they have over three hundred research laboratories in the empire, and each one is a veritable hive of industry. The training of the staff is of an extremely high order. No one is accepted unless he has extraordinary attainments, and, more than this, we find the same marvellous quality which has brought Japanese art down through the centuries to the perfection that it has reached, for instance, in the horticultural line, with the enormous patience and skill shown in the training of plants, shrubs, and trees. This same meticulous attention to detail, characteristic of the nation as a whole, is carried into the laboratories and from those laboratories we may justly expect great things in the future, not only from this standpoint, but with respect to products such as those already turned out as a result of various activities, only one or two examples of which I have mentioned above.

The late American Ambassador to Japan, Mr. Charles MacVeagh, stated that one of the greatest things that he had encountered in Japan was loyalty. Had Mr. MacVeagh been technically inclined and had he been given opportunity to observe some of the technical advances, both those originated and produced in Japan and those adopted from the western world, he would have envisioned another even greater achievement or characteristic of these people, and that is courage. As we think of it, this receives full corroboration in what we know of the wars of both defence and aggression, beginning with the vast invading armies of Kublai Khan and down to the present day.

The world's estimate of the value of an invention is reflected in letters patent — a clever invention in and of itself, which was devised in Great Britain and first adopted as a government measure in 1624. By this clever device the inventor is induced to make public his secret in exchange for a highly prized government grant of a monopoly for a limited term of years, varying in different countries and averaging about sixteen years. The great extent of industiral activity existing in various countries is shown by the enormous number of patents issued. Although we are issuing in the United States about eight times as many patents as in the rest of the world, per capita we fall far behind one other country, Switzerland, which has been noted for centuries for its ingenuity — traced by competent analysts to the driving out of the Huguenots from France in the seventeenth century. The per capita ratio is 5.4 to 3.8. The English profited similarly by an influx of Norman blood. These patents are almost wholly for inventions only, a few being for discoveries.

In preparing this statement I have very naturally tried to see how it fitted into my own experiences in the subject before us. Think as I may, I cannot discover any time in which I have felt in the course of my work that I was performing any of the acts usually attributed to the inventor. So far as I can see, I have come up against situations that seemed to me to call for assistance. I was not usually at all sure that I could aid in improving the state of affairs in any way, but was fascinated by the challenge. So I would study the matter over; I would have my assistants bring before me everything that had been published about it, including the patent literature dealing with attempts to better the situation. When I had the facts before me I simply did the obvious thing. I tried to discern the weakest point and strengthen it; often this involved alterations with many ramifications which immediately revealed the scope of the entire project. Almost never have I hit upon the right solution at first. I have brought up in my imagination one remedy after another and must confess that I have many times rejected them all, not yet perceiving the one that looked simple, practical and hard-headed. Sometimes it is days and even months later that I am brought face to face with something that suggests the simple solution that I am looking for. Then I go back and say to myself, "Now I am prepared to take the step. It is perfectly obvious that this is the way to do it and that the other ways all have their objections." It usually transpires that the innovation-resisting public will find any amount of fault with the one that is finally chosen. But I have always been tolerably well fortified because I have the feeling that I have made a pretty thorough canvass of the methods which would in all probability occur to the other workers in this field.

The way I started with the applications of the gyroscope might serve as an illustration of this. First I had somewhat of a library on the gyroscope. Almost without exception these books and pamphlets were terrifying in the profuse use (I have often thought it rather in the line of abuse) of higher mathematics. These did not serve to get me very far, but our family was blessed with three boys and I tried to keep these youngsters supplied with gyroscopic toys of various varieties, some of which I imported. I got more out of these toys than the boys did, inasmuch as they served the very useful purpose of putting me wise as to the magnitudes involved in the gyroscopic reactions that I knew about. These latter were more or less familiar to me, but the former in some respects astonished me. I never would have realized the possibilities had I not been able thus to visualize them while they were actually taking place.

I at once saw that the gyroscope had four properties capable of performing great services: (1) the "muscle" of the gyroscope, (2) its directive power, (3) its persistence in plane, and (4) as a remarkable multiplier of angular velocity.

Of course these have gradually unfolded and some uses falling under these various heads have been suggested by the success of the gyroscope in the other applications. My work upon their development and application was measurably in the order given.

The adaptation of the gyroscope to increase safety at sea derived a tremendous urge from the rapidly growing difficulties in the use of the magnetic compass, especially on men-of-war and any ships possessing large armament that could swivel, every movement in the direction of which would practically put the magnetic compasses out of action. The gun is a great magnet and its accidental heading with reference to the magnetic meridian when last fired will often cause complete reversal of its magnetic conditions and thus render the magnetic compass useless.

The problem with which I was confronted in the compass was the fact that my "compass needle" had to be a ponderable wheel of considerable weight, continuously spinning at high speed. This, of course, could not be suspended by a minute point, as in the case of the magnetic needle. Inasmuch as the self-directive power of every meridian-seeking device of all classes is always zero when it is on the meridian, this fact alone makes absolute freedom of orientation the prime consideration. How could a great ponderable mass approaching one hundred pounds be suspended with even more freedom than the magnetic compass needle? The demand for nothing less than a complete solution of this detail is emphasized by the fact that the gyroscopic reaction at its maximum is an extremely feeble influence. The earth's rotation delivers to the gyro compass only 1/14,000 of a radian per second of angular velocity, which is the only force available for its functioning. Many of our powerful gyroscopic reactions have available many radians to produce the results. So, outside of the many problems of damping and suppressing numerous other disturbances, these two paramount considerations had to be met in a way that would be permanent through the years and absolutely practical in the hands of the unskilled. This proved to be no small task, but some four thousand of these compasses now operating on all the seven seas is evidence of the success of the methods employed.

After my first gyro compass had completed its sea trials, I at once realized that it could be made to perform many additional and very desirable functions. These were gradually perfected. Among them are the complete azimuth base for all automatic fire control for ordnance on battle and other naval ships, the automatic orientation and control of gun mounts, turrets, range finders, etc., complete automatic steering of ships through the gryo pilot, known popularly as "Metal Mike," the operation of the course recorder, making a record of every change of heading of the ship with an accuracy of 1/6 of a single degree, plotted against chronometer time. Other uses are constantly appearing.

Referring now to the application of the gyroscope for preventing all roll of ships, this has been slower of adoption through the extreme conservatism and inertia of shipping interests. In about fifteen years only about forty installations have been made. At first we did not understand how much roll-quenching power different-sized ships required, but after the second installation had been completed this lesson was learned and the equipments adopted since this rule has been known and carried out have been entirely successful in preventing the ship from ever breaking away and starting its first roll.

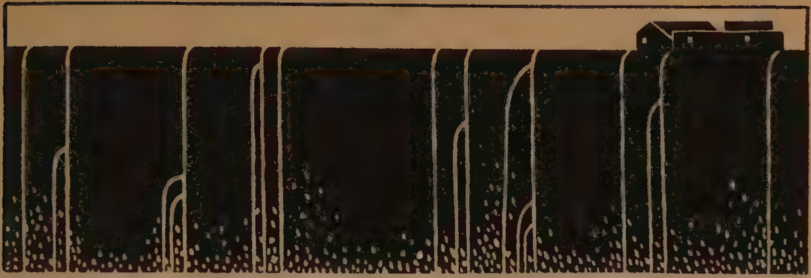
All rolling of ships is the gradual accumulation of individual wave increments after the ship has broken away and started its first roll, and the gryoscopic stabilizer is found to be completely successful in dealing with just this initial critical factor. One ship having the characteristics of a 16,000-ton merchant ship has now operated six years, the owners reporting a roll of less than 2 degrees on a side when other ships in the same fleet with the same characteristics roll up to as high as 20 to 26 degrees on a side. The long experience with this equipment, together with the ship's structure and all the related elements, has been so entirely satisfactory that orders have been placed for duplicate equipment having even more powerful characteristics. Its great value in affording a stabilized gun-platform has been completely demonstrated.

My work on this application was more in the line of a close study of all the various characteristics of rolling ships, and I determined that to be successful in suppressing roll everything depened upon the absence of lag and the high degree of exactitude of the emplacement of the counter forces. I refer to those forces that counter the forces due to each individual wave increment trying to roll the ship. These are all small forces. No single wave increment tends to roll the ship very much and if each can be successfully and entirely neutralized and with measurably complete synchronism, we have the answer. The ship always finds itself obsessed by two equal and opposite forces and therefore never can break away and start its first roll. We find it extremely simple to keep it continuously in just this state, where the forces of the waves arriving from one side or the other are simultaneously countered by equal opposing forces; in such conditions the masts remain absolutely vertical hour after hour in the most tempestuous weather. This, though an extremely spectacular result, is one that we find very simple of accomplishment.

The Japanese Navy finds that, even with constantly changing personnel, each new petty officer in charge has no trouble in operating the plant with entire satisfaction. The equipment is found to be so simple and robust and operates with such ease that not a single supply part has been requisitioned in six years of continuous service. When installed, this equipment was ten times as large as any equipment of the kind that had theretofore been designed and installed and great courage was manifested on the part of the Japanese naval engineers in its adoption, especially in the face of rigorous opposition on the part of the older conservative navies whose directors brought forth endless reasons why this large stabilizer could never succeed. However, these bold officers and engineers had reached their own conclusions and they moved steadily forward, undaunted by the learned finalities which all proved false. In the end their courage demonstrated to the whole world the value of this equipment in handling large ships and the entire shipping public is the gainer.

Among the other applications of the gyroscope may be mentioned its use for automatic flight of aircraft; stabilizing the base or artificial horizon line in gunnery; operating various aids to navigation and manual flight of airplanes, such as turn indicators and the artificial horizon; giving a valuable and accurate base line in oil-well exploration, making records all the way down to the depth of a mile or more; yielding a base line of high precision for recording inaccuracies in railway track, especially the cross level at all points, particularly at curves, a very accurate record being produced of the track, not as it seems to be to the track inspector, but as it really is the instant it is under full load and the impact of full speed. This serves to illustrate the intimate inner connections of the physical world and the value of speculative imagination in devising any instrument of varied uses which may be geared into the complicated mesh of nature.

From what has been said it follows that the potentialities of invention are not alone in the control of the inventor. In practice he does not merely move about in a wonder-world of his own creation; he acts chiefly in response to calls from the outside — needs apparent, or dimly understood, hopes kindled by experience. When he has achieved a given result, its effects pass largely beyond his hands and depend upon the imagination and venturesome spirit of the world outside. If modern civilization is troubled in its soul about the so-called evils of the machine, perhaps it is because it has not thought its way through its own problems and presented them effectively to inventive minds, which as I said in the beginning are widely distributed in the human race. Rather than to make scapegoats of engineers, it might be wiser to lay before them a work programme calling for invention as well as mere construction.



IV — POWER

By C. F. HIRSHFELD

ALL civilizations, no matter what their superstructure and values, rest on power. Before the advent of the steam engine, the power utilized was largely that of man and beast, although water-power was used to a limited extent and wind-power was drawn upon for propelling water craft and driving small mills and pumps. The civilization of ancient Greece rose to its dizzy heights mainly on the labor of slaves — probably, on the average, two or more for each free person. The civilization of the United States now has at its command power equal approximately to that of one hundred slaves for every man, woman, and child in the country — and yet not a single human being is sold at the auction block. Moreover in this epoch of electricity and the internal combustion engine, power is so widely distributed that it comes under the hand of the farmer on the lonely plain and the housewife in her home, as well as the producer in the factory. All that follows is, in a way, merely a commentary on these tremendous facts and their cultural upshot.

I

ONLY by a long process has this state of affairs been brought to pass out of the labors and aspirations of inventors, engineers, and the directors of industry. Historic man has always been physically puny in comparison with his mental stature. He appears always to have conceived of projects too great for him to perform physically and, conversely, his physical performance appears to have been limited by the magnitude of the forces that he could at the time command.

There has thus been a continuing urge to bring under control more powerful agents capable of materializing the dream children of his brain. The subjection of various beasts of burden and the devising of various lever systems and other mechanisms for the magnification of all too meagre forces mark the first crude but, nevertheless, epochal steps in this effort to meet the demands of an unexplained but plainly evident characteristic of *homo sapiens*.

It is not necessary to trace the widely separated steps by which the forces brought under subjection became slowly but surely greater or more powerful. Suffice it to say that, although many toy-like engines and water-wheels were developed and, later, several very crude and inefficient steam engines, progress was woefully slow until the serious development of the steam engine started in the early part of the seventeenth century and culminating in the famous patent application of James Watt in 1769. Watt's inventions finally gave to man the powerful tool for which he had been groping for many centuries. It is interesting at this point to note that the necessity of finding better means for pumping water out of mines and particularly out of coal mines was the principal driving force back of the inventions which ultimately produced the great coal consumer of the present day, the steam engine.

Progress in extending man's capacity for work through the use of power was comparatively rapid from that time onward. Continuing improvement was made in the steam engine until now we have available single units in the form of steam turbines which are many thousand times as powerful as the engines built and sold by Watt, and thermally much more efficient. The development of water-wheels which may be regarded as the progenitors of modern types started a few years after the appearance of the Watt engine and the improvements in these devices have kept pace with the evolution of that engine. Almost a century after Watt made the steam engine a commercially usable machine the serious practical development of the internal combustion engine began. Out of this have evolved the gas engines, gasoline engines and oil engines now so familiar to all that it is difficult to picture a condition of civilization in which they were not available.

The industrial epoch, or whatever one may choose to call the age in which we live, has been built about these means for enabling man more nearly to approach in accomplishment the pictures which his imagination paints. Many other inventions were needed and were forthcoming. It was necessary to create the manufacturing machines and processes which were capable of utilizing the quantities of power that could be made available. But, the foundation of the structure was and has remained the device for producing power greater than can be produced by human muscle or the muscles of beasts. This device, engine or water-wheel, is sometimes called a prime mover and will be so designated hereafter.

It happened that for many years after the production of such prime movers no means were discovered for transmitting power over great distances. Gears, shafts, and belts made it possible to operate production equipment within a few feet or a few hundred feet of the prime mover. Power could not be transmitted economically over distances measured in miles. Modern industry started therefore with a distinct limitation; manufacture by power had to occur adjacent to the power plant. And, in general, each manufacturing establishment had to have and operate its own power plant.

This limitation was not removed until toward the end of the past century when the electric transmission of power was made practical. From small and inconspicuous beginnings this means of carrying power from the point of production to a more desirable point of utilization has been improved and expanded until now it is possible to transmit economically over distances of about two hundred miles when technical and economic conditions are favorable. The indications are that even this relatively great distance may be exceeded in the not distant future.

No longer is it necessary that each manufacturing establishment shall have its own power plant alongside. The large centralized power generating assemblages known as central stations can now produce power in huge quantities and distribute to consumers of all sizes over widely spread areas. It is obvious that this characteristic development of the past few decades rests upon the production of practical means for transmitting electricity in large quantities over great distances.

Once more the availability of such means has produced the necessary inventions to make utilization possible. The electric motor, the electric light, and numerous other devices so extensively used in industry and in the home appeared in rapid and almost kaleidoscopic fashion.

It was not to be expected that man would begin to utilize steam and water-power for manufacturing, mining, water pumping, and other industrial and communal purposes and continue to use foot and animal power for travel on land, and wind-power on water. When the means for bettering transportation facilities became available human brains capable of adapting them to this specific purpose appeared. There resulted various forms of steam-propelled carriages and finally the locomotive and its train of cars for land transportation, and the steamship for water transportation. Later came the electrically propelled street and interurban cars and then the gasoline engine driven motor car or automobile. And finally we have the gasoline-propelled craft for aërial transportation, the airplane and the dirigible.

The availability of power has also had its effect upon communication systems. True, there were electrical means of communication depending only on chemical batteries for power before the generation and transmission of electric power were commercialized. But, it is now almost impossible to conceive of our complicated and multitudinous means of communication without bringing modern power production into the picture also.

II

THE literature of our day contains many references to the availability of power and to the significance of such availability. Various governmental agencies throughout the world collect and issue statistics on this and allied subjects. But very few people whose daily business does not bring them into forceful contact with the matter have any very clear picture of what it is all about, what quantities of power are now available to, and used in, different human pursuits, and how rapidly the proportions are changing. It seems logical therefore to endeavor at this point to paint some sort of picture which, even though the strokes be broad and the colors crude, will convey a reasonably correct conception of the situation.

The United States of America is generally considered to represent better than any other country at the present time those things which are characteristic of the industrial age. It also happens that comprehensive statistics of the type needed for the present purpose are more readily available for this country than for any other. For these reasons the power picture will be developed for the United States. In passing, it may be remarked that those phenomena and conditions accepted as characteristic of the industrial age appear in the different countries in amounts and extents that are roughly proportional to the power used per capita and the geographic distribution of such use.

Statistics which are believed to be reasonably accurate indicate that if all engines, water-wheels, and beasts of burden, that is, all prime movers, be counted in, about 10,000,000 horse-power were available to the inhabitants of this country in 1849. By 1923 this figure had swelled to about 700,000,000 horse-power. Allowing for changes in the population of the country over the period, these values indicate less than one-half horse-power per capita in 1849 as against well over 6 in 1923. This change may be visualized by taking one horse-power as equivalent to ten men in work-producing ability. On this basis each man, woman, and child in the country in 1849 had the equivalent of five human slaves apiece continually available for service and by 1923, the equivalent of over sixty such slaves.

The growth since 1923 has been astoundingly great, so that the total primary power in the country today is well over one billion horse-power. The power available per capita is now probably equal to about 10 horse-power, so that each man, woman, and child now has the equivalent of about 100 slaves. Certainly no previous civilization could boast any such average. The famous freemen of ancient Greece are supposed to have averaged about two slaves apiece.

It is exceedingly interesting to note the ways in which such enormous quantities of power are used, particularly because the facts are quite different from the popular belief. We are accustomed to think of our huge central stations as the grand repositories of power-producing equipment whereas the fact is that, monumental as they are, their aggregate capacity represents a very small part of the total. For example, in 1923 agriculture possessed about 38,000,000 horse-power which was almost twice as much as the total central station capacity of the country and equal to almost 6 per cent of the total primary power of the country. The steam railroads used equipment totalling practically twice that used in agriculture. If all prime movers in central stations were assumed to have been used for supplying manufacturing plants, an assumption far from the truth, and their aggregate capacity is therefore added to that of all prime movers installed in manufacturing plants, the result would be to indicate the manufacturing plants as using approximately the same total capacity of prime movers as did agriculture in that year. It is interesting to note that even when thus falsely magnified, the so-called manufacturing industries would appear to have used only about 6 per cent of the total installed horse-power of the country and only about half as much as was devoted to railroad transportation. Quite contrary to popular belief, the facts indicate that a very small part of the total prime-mover capacity of the country is used for manufacturing purposes.

But, the most surprising part of all is that played by the automotive vehicles, that is, by automobiles, trucks, and busses. Almost three-quarters of all the prime-mover capacity in the country in 1923 was installed under the hoods of automotive equipment. And, still more remarkable, about 90 per cent of this huge fraction was accounted for by pleasure cars; that is, about 67 per cent of all the prime-mover capacity in the country was contributed by the pleasure type of automobile. Since 1923 the balance has swung still further in favor of the motor vehicle until now well over

80 per cent of all prime-mover capacity in the country is carried about on rubber-tired wheels. This is certainly an interesting sidelight upon the way in which we are using a very large part of our power-generating capacity.

Another interesting sidelight is supplied by the use of power in aviation. We still consider this as a very new and more or less unproved development. Exact statistics are lacking but it appears probable that possibly two million horse-power of prime-mover capacity is already used for such purposes. This is small as compared with the total capacity for the country but it already represents several per cent of the total power used for manufacturing purposes.

It is desirable at this point to introduce another fact because otherwise the reader would obtain an entirely erroneous impression. Thus far we have dealt only with installed capacity. It is equally important to determine the extent of use.

This may be expressed easily by means of a measure which we shall call the annual use factor. A use factor of 100 per cent will indicate operation at full load, that is, full output, every minute of the year. A value less than that means proportionately less than the maximum possible output per year.

The prime-mover capacity in the central stations of this country has, in general, a very high use factor, varying from as high as 75 or 80 per cent in a few isolated cases to possibly 30 to 40 per cent in the average, representative plant.

As against such figures, the pleasure automobile has an exceedingly low use factor. In the first place, such vehicles are very seldom operated many hours per year and, in the second place, they are seldom operated for long periods at speeds requiring more than a small fraction of the installed power. The outcome is that the prime movers of pleasure automobiles, on the average, probably have a use factor of the order of 1 to 2 per cent.

It results that, in spite of the fact that about 80 per cent of the total prime-mover capacity of the country is used for automotive purposes in comparison with less than 5 per cent installed in central stations, the total horse-power generated per year in each class is not very different. It is immediately obvious that some such measure as is afforded by the use factor must be included in power statistics if a very distorted view is to be avoided.

The fact is that in spite of the comparatively small amount of prime-mover capacity devoted to industrial purposes, our actual workers are amply well supplied with power. Workers in the manufacturing industries, as a grand average, have available almost 5 horse-power apiece or the equivalent of almost 50 human assistants while the average agricultural worker has still more power at his command. The industrial worker uses his equivalent of human slaves many weeks per year; the agricultural worker, however, uses his only a few hours per year.

III

Now, how shall we appraise the value of this youthful giant, Power ? How shall we decide whether his birth and growth have been for the good or bad of puny man who synthetized him from what he found ready to his hand and brain in Nature's laboratory ? How shall we predict whether he is serving to bring man near to those heights which idealists of all ages have pictured as his goal or whether he will prove a veritable Frankenstein that is now actually engaged in destroying his maker ?

As soon as we attempt such a valuation we are confronted with many difficulties. There is particularly grave danger of imagining a causal relation between phenomena which are only contemporaneous. The ease with which this is done is indicated by the readiness with which each advocate and each fanatic can prove the rationality of his position from past and current events. At the present minute the general prosperity of the United States is not only variously attributed to, but proved to be due to the huge amount of gold in the country, the war debts of Europe, the tremendous per capita use of power, Volsteadism and so on through as many individual explanations as there are ardent believers of different complexions.

It is essential that we recognize such facts and that we appreciate that when the present epoch is viewed in retrospect by our distant descendants they will probably assign quite different values than do we to the various events and phenomena which appear to us in certain definite relationships. In fact, to them our explanations of current events will probably appear just as weird and just as muddled as do many of the loftiest thoughts of the past to us of the present generation. What follows is written with a full realization of the limitations thus placed upon any current commentator.

We may say that it is generally recognized that marked changes in nearly all conditions of human existence have occurred since power has been available in large and controllable quantities. It is also generally admitted that many of these changes are directly or indirectly due to the availability and use of power and the things produced by power. It must, however, be recognized that many subtle changes from the older order cannot be attributed either directly or indirectly to our young giant. For example, the type of thought which is spreading outward from the scientific research centres is very different from that characteristic of earlier ages and it is having its effect just as surely, though possibly less tangibly, as is the output of the prime mover. As another example, there is certainly a growing appreciation of the fact that while a mind trained to think in the involved and abstruse realms of science is certainly trained along very different lines from that of the scholar of earlier ages, it may be that this new type of training represents a form of mental culture just as ethically and æsthetically valuable, as well as just as humanly satisfying, as the older type which formed at least the foundation upon which could be erected an edifice representing the true culture of its day.

It is probably not stretching the facts to assume that the availability of power in large quantities and low cost is, at bottom, responsible for the major materialistic domonstrations of the age and for many, but by no means all, characteristics of the less tangible expressions. If this be accepted as a correct statement, we may first consider in a broad way just what the materialistic effects have been and then we may endeavor to discover the connexions between these and the less tangible though possibly equally evident ones.

Throwing aside for the minute all individual items, we may say in a broad sense that power has served to greatly increase man's extensions in space and time. This means, simply, that he is less bound than formerly to a given place or restricted part of space and less bound, also, with respect to just what he must do at different hours of the day. In other words, he has been given greater mobility and greater leisure. Of the first there can be no question, it is evident on every hand. Of the second there may be doubt in the minds of a few. If these will interpret man to mean the great mass of civilized humanity and not a privileged few, they will undoubtedly admit the greater degree of leisure enjoyed by the masses of our present order.

The increased mobility quite obviously rests upon the use of power-driven conveyances of different sorts so that extension in space is definitely attributable to the ready availability of power. Extension in time can be shown, at least, to rest upon the use of power in the sense that it appears to us now to be impossible to any such extent under conditions which do not incorporate such use. In brief, the output per worker has increased at tremendous rates as more and more power has been made available to him. This process has extended over the best part of a century but has been increasingly evident as the real possibilities have become understood and as industry of all sorts has consciously planned to take advantage thereof. Thus, in the short period of the past decade the output per worker in the factories, mines, and agriculture of this country has increased about one-third. This of itself might have been economically and socially disastrous since it might have resulted merely in overproducing, throwing out of employment a corresponding number of workers and leaving those still employed no better off than they were before. But this is not what has been happening.

For reasons which need not be discussed here, the economic relationships which have existed in the recent past have been such that it has been possible for the employed worker to share in the savings resulting from his greater output. In the earlier periods of the industrial age the situation was quite different. Men, women, and even children worked to the limit of human endurance in order to obtain the bare necessities of existence and were then compelled to live, or in truth, exist under conditions which in the light of modern knowledge and practice are regarded as not even fit for the most lowly and least self-respecting of beasts. Now the worker actually gives 48 to 60 hours of his time per week to his employer and indications are that before long he will give in the more favored cases not more than 40. Allowing for eight hours sleep per night, a 48-hour working week leaves 64 waking hours per week not pre-empted. These are not all leisure hours since transportation to and from work and the eating of meals must be provided for. However, a large part of the 64 remains over, or may remain over, as leisure time. But, in spite of the shortened working hours, the economic balance is such, or has been made such, that the worker can earn in these shorter periods not only enough to house and feed the family on a scale not previously dreamed of as remotely possible, but a surplus with which to purchase such things as automobiles, radios, musical instruments, refrigerators, washing-machines, and many others regarded not so long ago as luxuries available only to the favored few.

Out of the leisure has come the physical extension in time and out of the surplus have come the means for the physical extension in space. The worker and his family now have time in which to do things other than those required for the obtaining of bare subsistence and the surplus enables them to spend the leisure time more or less pleasantly and, in a non-commercial sense, profitably.

Yes, says the pessimist, but you have forgotten that many have been thrown out of work because of the fact that the possible output per worker has increased faster than the ability of the community to absorb the products. It is true that this has occurred and it is true that unemployment has resulted. But, it is also true that the phenomenon is, under favorable circumstances, a self-correcting one. The surplus earnings and the leisure time in which to spend them appear to result in the creation of new jobs in a most complicated and almost endless fashion.

Workers with automobiles who take their families into the parks or into the country on holidays, on week-ends, and during vacations call for filling stations, parking and eating accommodations, and various other things which projected backward give employment to huge masses of individuals. The casual user of the automobile does not appreciate that back of the gasoline dispensed from the filling station lies a train of activities leading by transportation facilities to the oil refinery, and from there on the one hand to the iron mine from which were derived the raw materials for refinery equipment and on the other hand to the oil well from which were derived the raw materials out of which the gasoline is made. It seems hardly necessary to call attention to the fact that the same automobile habit has required the building of improved roads on a most extensive scale and with a huge labor account to its credit, which activity extends backward to quarry and coal mine and other original sources. And, it must not be forgotten that legal registration of automobiles, the collection of special taxes, the policing of traffic routes, and other incidental features, are in the aggregate responsible for many jobs previously non-existent.

The automobile industry was chosen for illustration because of its recent origin, its magnitude, and the extent to which modern production methods have been used to decrease the number of man hours required per unit of output. Others might have been chosen.

As another example take the moving-picture industry. It is self-evident that this could not be supported on anything like the present scale if the butcher, the baker, the candlestick maker, and all their present-day successors in our more complicated social structure, and all their wives and children did not make fairly frequent pilgrimages to the shrines of the silver screen. Obviously such pilgrimages evidence both the necessary leisure time and the necessary financial surplus which are now generally admitted to flow from a situation in which a few men displace many through the instrumentality of power. But see what happens as a result. There is a market for more cotton which serves as the raw material for the films and someone must work to produce that cotton; there is a market for still more cotton which serves as the raw material for the artificial silk which the ladies of the worker's family wear to the theatre as undies and stockings; there is a market for the iron and brick and stone out of which the theatre is constructed; there is a market for the talents of actors and others whose work goes into the making of the picture, and so on.

As another example, construction work of various sorts has been radically modified by the use of power. When a contractor made the excavation for a house or other building a decade or two ago he hired many men with strong backs to wield the necessary picks and shovels, and a number of horse-drawn wagons with drivers to carry away the excavated material. Now he employs a mechanical digger of some sort, such as a steam shovel, and he discharges the excavated material direct to automotive trucks. The digging equipment, operated by one man or two men, can handle per hour many times the amount of material that can be moved in the same time by a small army using the older methods. And the man using it in place of the pick and shovel uses brain and not brawn, sits or stands in a comfortable position above his work instead of wading around in dirt and muck in a most dehumanizing way, is fresh at the end of a full day's work and is paid a wage that could not be made economically feasible while the older methods were necessary. The use of power has lessened the cost of excavating each cubic yard in spite of the higher wages paid to the smaller number of men required.

Once more men have been thrown out of work as the newer method has supplanted the old. But, a few cheap picks and shovels and a few cheap wagons have been replaced by a costly power-operated digging machine of some sort and by costly automotive trucks. Once more, if we follow backward we find a whole string of new or increased production activities, leading upward to the final demonstration on the actual construction job. Men must work somewhere to produce the metal out of which these labor-replacing devices are made; men must work somewhere to fabricate and assemble their complicated parts; men must work somewhere to provide transportation from mine and factory to the excavating job; men must work somewhere to provide the fuel that these substitutes for human slaves or near slaves consume in lieu of food.

One might continue at great length and cite example after example. But they are substantially all the same in essence, if different in appearance.

Follow what route one will, the evidence all points in the same general direction. The availability of power gives those workers who are retained in a given industry the opportunity to produce more in less time, making it possible in an economically balanced structure to pay them enough for a short period of work to give them both leisure time and a generous surplus above necessities. There is a counterbalancing effect, in that workers are thrown out of any given industry as the production per worker increases. But, this is in turn balanced by the creation of new demands in old industries and the creation of new industries to supply the things needed to increase production and to give an outlet to the surpluses that were created. Thus the displaced workers are again employed.

It is a case of continuing readjustment to new conditions. And, it should be noted that these conditions are both economic and social. Carried on too rapidly, the movement would undoubtedly result in chaos. Carried on at such a rate as permits the necessary readjustments without too violent and too frequent wrenchings and breakages, it appears to be leading safely and reasonably smoothly to an ever-increasing extension of the wage earners in both time and space; the production of greater personal leisure and surplus. No one can now say how far this process can be carried. It has been unbalanced many times but it has not yet actually broken down. In so far as one can see, there is no reason why it should ever break down if handled with sufficient skill and provided its raw material, namely, the contributions of original thinking and invention, is not cut off.

Extension in time has also come about through the use of power in a way not considered in the preceding paragraphs. A relatively small amount of artificial illumination is produced by candles, oil lamps and gas lights in the more highly civilized countries. Electric power is back of practically all artificial lighting in at least the more thickly settled communities. The cheapness, flexibility and ready availability of electric illumination is rapidly wiping out one of the limitations to man's activities which has been with him since his very beginnings. No longer need he consider his active day as the solar day, or as the solar day imperfectly extended a brief space through the use of inadequate, shadow-casting, and air-vitiating illumination. Night may now be made equivalent to day as to its effects upon work, study, pleasure, or amusement. Man may now choose of the twenty-four hours almost as he likes and an inherited limitation to his time extension is thus being rapidly removed through a characteristic and spreading use of the latest and most flexible form of power.

IV

THERE is no doubt but that, in a material sense, the mass of humanity in industrialized countries is much better off today than in any other epoch of recorded history, and this is particularly true in this country in which the industrial development exists in most modern, most perfected, and most extended form. But, is this all that our young giant Power can do for the world? Is his contribution limited to the bequeathal of full pockets and fat tummies to the masses? Is his advent to result only in the fast-moving, noisy, and nervous form of civilization which is so all prevalent that many take it as the necessary and only important characteristic of the age? Are we all headed for a time in which work will be done at such a hectic place, under the drive of unrelenting and impersonal power-operated machinery, that taut nerves cannot recuperate in leisure leisurely spent, but must find stimulation through equally hectic pleasures, until the race breaks down because its nervous system, or even its physical system, proves insufficiently resilient to withstand the pace? All these things and more have been accepted far and wide as characteristic and have been employed in accusations against the social order that has resulted from the generous use of power.

In this world it seems seldom to be vouchsafed that the worker, however conscious of his task, shall be able to appreciate its true significance or portent. Therefore, it is not now reasonable to assume that one who has devoted a good part of an active life doing his small share in the mechanization of civilization should be able to read completely the riddle of its full import. However, if this one has gone about his work with his senses open to the activities and movements about him and has given daily thought to the probable or even possible significance and meaning of the various developments and trends observed, it may be assumed that the mental concepts and pictures that he has evolved may possibly reflect, crudely and imperfectly but at least reasonably, the big underlying currents which the smaller surface waves and swells give evidence of. If this be the case, the ideas in this regard of such an individual may have some small worth in an effort to evaluate our present status and particularly what it portends.

Let us start by calling attention to the fact that that which we are recognizing and which we are discussing is of such short-time duration that, in the grand panorama of the development of civilization, it is an instant in a long lifetime. Its beginnings are hardly a century behind us. And the evolution in which we are now particularly interested is hardly more than two or three decades old. Truly, these are short periods on which to base extrapolation. It is almost as though one studied the initial circling and rather rambling flight of a bee leaving the flower from which it has finally extracted its fill of sweet juices, and endeavored to predict therefrom the direction of that bee line it will ultimately take when headed for its hive.

Let us view the human race historically for a minute. Has it as individual or group ever given any evidence of being so mentally constituted that at first it used profitably, in the broadest sense, any new ability that it acquired ? I think all history shouts strong negatives. There have always been experimental trials in the nature of play, or acquisition of power or position, and even abuse of power, before in the course of time the new instrumentality settled down into well-ordered grooves to contribute its modicum to the real advancement of man and his civilization, if indeed it possessed such capabilities.

Why then should we now lose heart if with the almost instantaneous acquisition of surpluses both temporal and financial, the masses, suddenly liberated from serfdom and slavedom or their very near equivalents, stage a modern version of a bacchanalian orgy? Why should we even think for one minute that this very characteristic and historically expectable reaction is any more than a passing demonstration over a newly acquired ability?

I think we are all confused by the results of a great many things that have happened more or less contemporaneously. Each of these has had reverberant and even repercussive effects upon a form of civilization, a code of ethics, a formula of thought, a system of inherited beliefs; so that many of us now stand aghast, picturing the ruin of all that we have accumulated through the ages and looking dismally ahead into a chaotic future.

To mention only a few, we may start with the modern and comparatively recent, wide-spread development of experimental science. Here is a most powerful weapon, still in crude form, which is enabling us to dig deep into the facts of the universe and to explain to a certain extent the phenomena that man has observed through centuries. Most frequently the explanations are at variance with inherited belief. One cannot thus topple over the foundations on which our civilization has rested for years without expecting quite a considerable collapse of the superstructure. From an engineering point of view, it is really remarkable that the entire superstructure has not shaken down into the smallest fragments and buried itself with its foundations. We are now very busily engaged in building a new foundation with partly cured and very imperfectly shaped materials and at the same time buttressing and modifying the superstructure with respect to shape and adornment, so that it may both be supported upon the new substructure and appear reasonably consistent therewith. Wonder of wonders is it that we still have the superstructure to work upon.

And while this thing has been going on we have developed a new type of mental culture. No longer are the best brains devoted only to study of the humanities, to the milling over and analysis of the acts of men and nations long ago passed on, to the abstract consideration of the relations of man to man and of man to the universe. Some of them are producing a new form of culture which appears more materialistic, possibly merely because it is basically less abstract. This refers naturally to the forms and character of thought, the ideals and the philosophies developing in the minds of those wedded to science or merely appreciative of the findings of science. The exponent of the old contends, as man has always done, that his is the only true culture; the exponent of the new is not so caustic about the old but insists upon the value of, and a reasonable chance for, the new. Right in the middle of a troubled era of tumultuous changes of all sorts we find ourselves engaged in formulating new definitions and evaluations of culture, as if we did not have enough to do without that added burden.

Moreover, we have brought the mentality of the masses into affairs in new ways. Education on a magnificent scale has spread ability to read. New methods of printing, publishing, and distributing, all based on the extensive use of power, have carried to the masses information and speculative thought, theory and practice to a previously undreamed of extent. We have developed almost overnight a very large fraction of the population to the place where it feels competent to make decisions for itself in matters which were previously accepted on faith or on the word of parent, overlord, state, or church. Thus we have acquired an active fermenting mass in place of the previously more stolid and fatalistic stratum.

No longer does authority of any sort prove sufficient answer. There must be reasons, and they must at the time be sufficiently plausible to gain acceptance. Questioning of the so-called eternal verities by masses mentally enfranchised so recently is but a natural consequence of the discovery of the extent to which the world they now see differs from the world they were previously told existed.

And then to complete the confusion, we develop in a very short space of years an industrial and economic system which makes it possible for these same masses to satisfy appetites of all sorts which have always existed but may now be appeased for the first time. Reference is not made only to those physical appetites such as a craving for good food, luxury, and the like, but also to others of a higher and more advanced type which might possibly be called aspirations. We may mention for example the desire for ownership in home, land, or industry and the desire to give offspring an easier and fuller experience and life than that of the parents.

Is it any wonder that we gaze on in awe at the world apparently gone mad? Mad it is when viewed with the mental attitude of the upper class of only a few years back. Is it any wonder that those who bethink themselves view with alarm the potentialities of the tremendous new forces that have been put into the hands of babes? Is it any wonder that the literature of the day is filled with diatribes against the new order of things which many feel might better be called the disorder?

But, look you. If you will forget a moment your preconceived or inherited ideas, a difficult task I admit, and gaze through the surface demonstrations, it is possible that you may see in the undercurrent certain things that point the way in which we are headed.

Certainly we can see greater charity between men, at least in a communal if not in an individual way. Public hospitals, community funds, homes for the infirm, the physically sick, the mentally ailing, and even for the social sinner. No longer are these unfortunates forced to beg alms on the street corner, left to die unheeded in the gutter, or stoned out of the community to fare as best they may, and the devil take the hindmost. There is a new evaluation of the importance, yes, the sacredness of human and even animal life. Out of the industrial civilization, which started as a callous converter of the strength and substance of human body and mind into physical wealth for a few, has emerged a new and certainly a higher view regarding not only the inviolability of the individual but also the social responsibility for the individual. In all the rushing tumult of the modern city, the ambulance has the right of way; this should not be forgotten.

Certainly we give more heed to the welfare and needs of the children of the urban community than we did until a very short time ago. As we learn how, we provide parks and playgrounds; we insist upon certain minimum requirements regarding both safety and sanitation in dwellings. We should not judge only by the present conditions, which admittedly are still capable of much improvement; we should compare these with the conditions of the past, and we need not here go to the very remote past either.

And, there is a growing appreciation of the social and economic rights of the under dog. He is protected against exploitation of all sorts in so far as we have been able to appreciate the needs and to devise the means. He is protected against excessively long hours of labor and against practices of various sorts which lessen by subterfuge the wage received. He is protected against substandard food, diseased or adulterated. He is even protected against the normally expectable, and sometimes even the just deserts, of his own voluntary acts. And it now looks as though before long he will be protected against lack of earning ability in his old age.

Further, there is a growing tendency to apportion the burdens of civilization most equitably over the shoulders of its constituents. The broadest shoulders are being given the heaviest burdens in marked contrast to the time when the strength of the broadest was used to heap well nigh impossible burdens on the narrowest. The graduated income taxes and the inheritance taxes are among the best examples of these tendencies.

Another very significant thing should not be overlooked. It is the growing tendency of the superlatively successful to recognize the existence of an unrecorded but nevertheless real debt to the society which made their achievements possible. Hence the foundations of various sorts for increasing human welfare, and hence the increasing degree of free service rendered to individuals and communities by those who have reached eminence in particular lines.

These things are all in a sense socialistic, using the word in its literal meaning. In another sense they stand for an increasing understanding and appreciation of man as an individual. It is rather curious, but very hopeful, that such things should appear among the fruits of the power era. That which started to digest men, women, and children in the maw of mechanical industry, that which started to convert them into little more than parts of the mechanisms that they tended, turns out to be a great stimulant toward humanitarianism before it is more than really adolescent.

It may be that mankind has always been desirous of doing such better things but that the doing of them was previously impossible. It must be admitted that many great teachers of religion and of philosophy have preached such doctrines through the ages.

But they seem, until recently, to have fallen upon more or less deaf ears in so far as their practical application goes. However, for our present purposes, it is not necessary to determine whether such higher ideals and practices in the communal relations of man are demonstrated extensively now because of the fact that the use of power and the things that it has brought with it make these demonstrations possible, or whether the newer practices flow in some obscure way from the materialistic factors of a power age. Suffice it that the two are contemporaneous and that we cannot, in retrospect, see any practical ways in which the presently accepted communal standards could have been possible in the ages before the extensive use of power.

If these observations be sound it would appear that, in one way or another, the inventions which gave to the world substitutes for back-breaking human labor, that is, prime movers, ushered in many unexpected blessings of another sort. It would seem that, for the first time in human history, there appears in the civilization founded on the prime mover and its potentialities a wide-spread, real, and practical recognition of the brotherhood of man. It would appear that the liberation of the masses has in some way introduced a leaven more fruitful of practical results than all the preachings of the ages, or else that a leaven already existent has for the first time found a medium in which it can grow actively and fruitfully.

V

Man is so constituted that he likes to look ahead. He wants always to discover what is just around the corner and, if possible, around the corner beyond that. It is an interesting exercise, but it must be admitted that its principal practical results thus far have always been the stimulation of the imagination and the production of entertaining fiction. Any attempt to indicate in more than the broadest way what may be expected next from the use of power must, in the light of human experience, be regarded as of questionable prophetic value. Therefore that which follows should be read with a full appreciation of such limitations.

It is now evident that one of the next great movements of materialistic type will be the liberation of the housewife, urban, suburban, and rural. The wide-spread availability of electric power and small gasoline engines, together with labor-saving household devices adapted to be driven thereby, is already having such an effect and the movement has only started.

The use of electric power by the urban and suburban housewife is understood by many. Few realize, however, the great number of electrically driven labor-saving devices which are already available but not yet in popular use. Still fewer realize the extent to which electric service is now being extended to the farm. Between 1924 and 1927 the number of partly or completely electrified farms in twenty-seven representative states almost doubled. The number of farms receiving electric services in the United States is now probably somewhere near 400,000. While this is still less than one-tenth of all the farms in the country, the movement has gained such headway that a very rapid and significant enlargement of this fraction is expectable.

What is the liberated housewife going to do with the surplus time? Since she is human, she will probably start in most cases to fritter it away in non-essentials. Equally, however, since she is human she may be expected ultimately to find ways and means of utilizing it more profitably. At the start we may expect that a woman released to a great extent from the drudgery and fatigue of the older methods of keeping house will not have her nervous system drained to the same extent as did her sister of yesterday. It is expectable that she can give more time to the mental needs of offspring if she is not required to spend most of her waking hours in providing for the physical needs of her family. She can, if she so desires, give more time to community affairs, to her own mental or physical development; or she can engage to a greater or lesser extent in business or profession.

And, it should not be forgotten that what is said of the housewife applies also to the unmarried daughter. She may be released from the necessity of helping the mother in keeping the house a going institution.

It may be that a future husband will suffer from her lack of experience in household duties but he will be compensated to some extent by acquiring a wife still freshly girlish instead of already marked with that stamp which distinguishes the wielder of broom and dish-rag and the caretaker of young children.

It is also now evident that the use of power is making it progressively more possible for those dwelling in the smaller cities to have many of the materialistic and the cultural advantages that were once characteristic of only the largest centres of population. And in many cases even the rural resident can, if he so desires, drive into town of an evening, avail himself of pleasures of one sort or another there procurable, and return in time to be able to get his sleep and rise betimes for work the next morning. Or, if he be too distant or he does not desire, he can sit at home and with the mere twirling of a knob bring to himself the sermons, lectures, and music of the largest cities thousands of miles away. Certainly life under such circumstances may be made more full and more satisfying. And we have every reason to believe that such possibilities will become both greater and more diverse as time goes on, so that the presently existing mental gap between city and farm will be more nearly bridged.

Further, it is evident that the manufacturing city is rapidly growing out of the stage in which it regarded the extent of the smoke pall that enshrouded it and the amount of dirt in evidence as indicative of its prowess. These blots on the landscape which still typify modern industry to many people are passing out in favor of smokeless, clean, well-kept, and orderly communities. The engineer has learned how to burn fuel smokelessly for power generation and how to conduct most industrial processes in cleanly fashion. The industrial executive has learned that his work is best done by workmen whose factory and home surroundings are such as to make them upstanding, self-conscious, and respected members of the community. There is also in evidence a growing tendency for manufacturing corporations to spread out into the smaller cities. This is made possible by power transport of various sorts, by power-operated communication systems and by adequate power transmission to the smaller centres. Thus industry is in a sense reversing the movement that it started; it is now tending to produce a large number of small and pleasant cities instead of a small number of large and unpleasant ones.

And what shall we say of the future of the large city; that characteristic conglomeration of architectural dreams and architectural monstrosities, of noises and nervous scurrying, of noisome smells and disagreeable sights, of contrasting goods and bads of all descriptions? Merely this. The large city as we now know it is just beginning to find itself. Its present form is a quite logical consequence of the first application of power to thickly settled communities. But, one who looks can already see the changes that are prophetic of the next stages of development. Streets are being made wider so that they may accommodate the ever-increasing automotive traffic. Purely utilitarian, but wider streets mean much better access for sunshine and fresh air so that utilitarianism has redeeming qualities. Building designs with frequent step-backs are being evolved so that not only does the street below suffer less shadowing but also that the occupants of the buildings have a new sense of freedom and contact with outdoors. Architectural shapes and lines and building materials and methods adapted to the treatment of high structures have been and are being worked out, so that there is at least hope that those who are willing to be guided by competent architects may become responsible for things of beauty rather than for such poorly conceived, poorly proportioned, and generally abominable perpetrations as have made hideous so many of the sections of our larger cities. There have even been evidences of attempts to treat huge areas of cities consistently in an architectural sense, so that the higgledy-piggledy appearance so characteristic of urban perspectives is to this extent eliminated.

These things and others already referred to are gradually moulding our cities along new and better lines so that they begin to possess certain æsthetic values in addition to those of purely utilitarian character. Now that the way has been discovered, it is not unreasonable to assume that it will be followed by ever-increasing multitudes as the years accumulate. But, this is not enough. We still have the noises, the nerve-wracking turmoil, the endless whines and rumblings and screechings so trying to those of sensitive make-up. Such things are undoubtedly more or less natural results of the accumulation of many individuals in restricted areas. Indeed they are characteristics dearly loved by some and it is doubtful if they are really harmful in any sense to such. We have only just begun to consider possible methods of amelioration. And, fortunately, the available methods appear to be numerous and promising. To mention only one, we are rapidly learning how to weld together without noise the structural frames of steel buildings, thus displacing the machine-gun-like voice of the riveting hammer. One may now confidently say that when public conviction becomes sufficiently great to justify the assumption of the necessary burdens, the city can be quieted down to a considerable extent in so far as the so-called city noises are concerned. Naturally one will still be able to hear one's neighbors if they collectively or individually decide to celebrate in noisy fashion.

It may therefore be prophesied that the large city of the future will be smoke free, or nearly so, airy, clean, reasonably quiet, better planned and built, and in all respects a better place to live in than is the city of the present. The methods are now largely available; it remains for the city dweller to make up his mind to utilize them. The fact that he is beginning to do so here and there may be taken to augur well for the future, even though no great amount of progress is now evident.

There also appears to be under way another development of great significance in this connexion. The automotive vehicle has been responsible for the creation of wide and well-paved roads between the larger centres of population. The tendency is more and more toward making these roads speedways to facilitate rapid travel from centre to centre. A careful study of many of these roads will show that there is gradually developing under our very eyes a new form of city and a new distribution of population which is highly interesting.

The road itself is tending to become what may be called a string city. Starting with filling stations, restaurants, and inns, there is a continuous building-up of business places of all sorts along both sides of these roads, forming in very truth one long business street. Behind these business places, and extending out into the country to convenient distances, are to be found suburban residences of urban workers. And still further back from the roads appear the agricultural developments that provide the food and many of the raw materials. The most significant thing about this movement is the fact that the suburban residences are not confined to the wealthier classes. The factory and office worker is also often a suburbanite. It must be admitted that at present the more poorly paid are apt to live in only slightly less congested fashion than they did in the city but they do at least have green grass and trees in front of their homes and some sort of a garden behind them. And, their children do have an adequate supply of fresh air and a place in which to exercise the ever-restless bodies and limbs of youth.

Such developments patently rest upon the availability of power in large quantities and at low cost. Otherwise we could not spread cities out for miles on end and ever hope to gather people in for their daily work and send them home again when that work is finished. It is indeed interesting to speculate what further changes may result from man's application of power to the conquest of the air and the substitution of speeds measured in hundreds instead of in tens of miles per hour.

Naturally, the growth of such string cities will occur first and to the greatest extent in the more thickly settled regions and particularly those in which manufacturing industries are well developed. It is hardly reasonable to expect such things in the thinly settled, non-industrial sections of the country. But, these sections also appear to be headed for drastic and far-reaching changes.

Agriculture is practically the only form of human industry, excepting the real professions, which still remains on an individual or family basis in this country. And those engaged in it suffer proportionate handicaps. They must in one sense or another have all their eggs in one basket and they must in general be limited by the extent of technical knowledge, financial ability, and financial resources which one individual or one family can command.

The manufacturing industries wiped out such limitations long ago through the adoption of the corporate form of organization. Indeed, it is problematical whether any such industrial development as we now know, involving as it does tremendous investments in productive equipment, could exist on an individual or family ownership basis. The corporate form has done many very obvious things for industry and it appears as though it might do a great deal more for agriculture if adopted in that field. A few minutes thought will show that large corporations engaged in agricultural pursuits would be able to command the financial resources required for the maximum utilization of power in agriculture, would certainly be able to scatter their holdings geographically and to diversify their products, would be able to employ specialists in the different lines of endeavor and, above all, would be in a much stronger marketing position than any individual agriculturalist or any co-operative group.

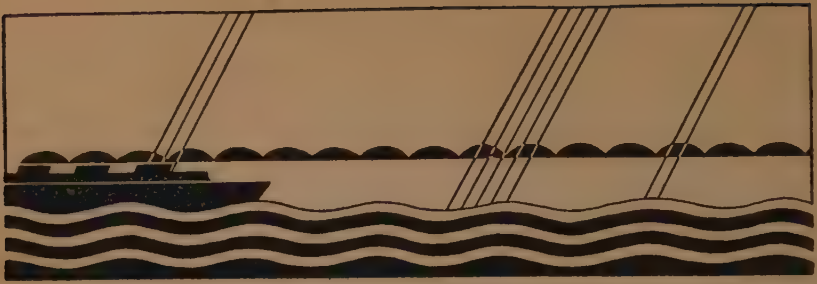
It is a fact that there are already many corporations engaged in agricultural work. It seems probable that the movements and ideas which have developed and are developing from the extensive application of power to human pursuits will, during the next half century, result in the extensive development of the agricultural corporation. Undoubtedly there will be many who will regret the passage of the independent and self-reliant farmer. There have been equal regrets over the passage of the independent and self-reliant manufacturer. And it is not beyond belief that, viewed in retrospect, it will be discovered that while the agriculturist has given up much that goes with independence and self-reliance he has received in exchange many other valuable and desirable considerations. The farmer turned wage earner will probably resent the change at first but he will in general receive more real wages and he and his family may ultimately expect to profit thereby in the form of release from worry and responsibility, greater purchasing power, greater opportunities for education and a generally higher plane of existence.

VI

It would appear that our young giant Power even in his adolescence has already set men free in a most astounding fashion. He has made it possible to realize many dreams that have been fomented in man's brain for ages. He has given the masses such opportunities as they have never before even come within sight of, to say nothing of possession. He has lifted the burden of the day's work from the shoulders of many and has placed it upon the unfeeling metal bodies of machines. He has opened up vistas of progress, of accomplishment, of improvement, of real worth that are indeed both intriguing and inspiring.

It remains to be seen whether humanity in mass is capable of using advantageously such rich opportunities. If it is, no one can say how far the race may go. If it is not, the dire prophecies of the pessimists of the age may be expected to be fulfilled. But, at least, we need not side unquestioningly with the pessimist because we do not observe on the part of newly liberated masses an immediate rush to higher cultural forms instead of the obvious satisfaction of much more lowly appetites and aspirations. There is hope in the fact that release has not resulted in more destructive and still less profitable pursuits and demonstrations. There is hope in the fact that the children of those but lately enslaved are flooding our schools and colleges to such extent that the provision of facilities has become a real problem. There is hope in the gradually changing character of the entertainment patronized by the great bulk of our population. There is hope in the tendency toward suburban residence. There is hope in the acquisition of homes, of securities, and of life-insurance policies.

This particular student of his fellow-beings, while recognizing how far we still are from what may be now imagined as an attainable goal, feels very certain that millions of feet are more or less unconsciously treading the wide road leading toward that goal. And he believes firmly that, as Power more and more liberates us all from the doing of the more lowly and time-consuming things having to do with mere living, we shall all learn to live in a fuller and more satisfying way. Whether this means that we shall devote long hours to communion with Nature in the field or in the laboratory, whether it means that we shall build up new philosophies and new and more enlightened versions of the verities of the universe, whether it means that we shall attain and maintain new heights in art and in letters is after all more or less insignificant in comparison with the question of whether we shall continue to develop and to practise greater charity and to produce less human and more humane relations of man to man. And this I think our young giant has actually brought about, or at least facilitated, in most astounding measure and may be expected to advance to ever higher levels. If this be true he has indeed been a large and potent factor in leading humanity toward civilization in the truest and most meaningful sense. If it be true, the synthesis and application of power to human affairs is certainly one of the things of which man may be most justly proud as an epochal step in his upward progress.



V — TRANSPORTATION

By Roy V. Wright

IN 1803," says Bogart, the economic historian, "Thomas Jefferson said it would be 1000 years before the region east of the Mississippi could be fully settled. If the people had been compelled to depend exclusively upon natural waterways and roads, this would probably have been true."

By this brief and simple statement the deep significance of mechanical transportation for the development of American civilization is given high illumination. It takes but little imagination to expand this idea into the wide reaches of our social evolution and to give a new meaning to obscure pages of our national history. And from this concrete starting point it is only a step to the consideration of mechanical transportation as a means of transforming the face of the earth and the economy of all the nations on it.

The material prosperity and advancement of a nation are quite as dependent upon its transportation facilities — their extent and the efficiency with which they are operated — as they are upon the efficiency and volume of production in general. Transportation and communication facilities, combined, are measuring sticks by which we can determine with some degree of accuracy the stage of civilization to which a nation has advanced. We can find striking illustrations of this by comparing the transportation facilities and life of nations in different parts of the world.

We take so much for granted in these days! Despite the comparatively simple conditions under which those of us now beyond the half-century mark lived, say forty years ago, we forget that our fathers had even less of what are now regarded almost as the necessities of life. We fail to recognize that our forbears of 125 or 150 years ago led an almost primitive existence. This is clearly set forth in a statement made by Dr. R. A. Millikan in an address before the American Institution of Electrical Engineers in 1917:

> Do you realize that within the lifetime of men now living, within a 100 years or 130 years at the most, all the external conditions under which man lives his life on this earth have been more completely revolutionized than during all the ages of recorded history which preceded? My great-grandfather lived essentially the same kind of a life, so far as external conditions were concerned, as did his Assyrian prototype 6000 years ago. He went as far as his own legs or the legs of his horse could carry him. He dug his ditch, he mowed his hay, he did all the operations of his industrial life, with the power of his own two arms, or the power of his wife's two arms, with an occasional lift from his horse or his ox.

We forget that it was but little more than a hundred years ago that the steam locomotive and steam-propelled vessels came into being and that slow progress was made in the building and extension of railroads and steamship lines in the decades immediately following — that is, slow compared with the progress during the decades of the last half of the nineteenth century.

It was not until a number of years after Jefferson made the statement quoted at the beginning of this chapter that the era of canal building began in the United States, or that the first railroad building was started. It comes as a severe shock to most people to realize that up to the nineteenth century most of the commerce, such as it was, was carried on by means of boats propelled by man-power or wind-power, or drifting with the current on natural waterways, and that even the best roads or highways were most unsatisfactory.

We have the eighteenth century testimony of Tobias Smollett when, in his "Humphry Clinker," he makes his character, Squire Matt. Bramble, say: "Considering the tax we pay for turnpikes, the roads of this country constitute an almost intolerable grievance. Between Newark and Weatherby, I have suffered more from jolting and swinging than ever I felt in the whole course of my life." And the conditions of which Matt. Bramble complained were the general rule — not only in England but elsewhere.

The age of mechanical invention started after the middle of the eighteenth century, but it could never have progressed far had not transportation been improved to distribute the products which the machine era was capable of producing. Of what use would it have been, even if the necessary raw materials had been placed by nature alongside a supply of natural water-power, if there had been available no effective way of getting the finished products to the prospective user?

Even as early as the sixteenth century the traders in England recognized that trade and commerce could not be built up and extended until the roads were improved. "It was not until the winter of 1745, when the government was nearly overthrown, mainly because of the bad state of communication between various parts of the country, that England really woke up."[1]

Some improvement was made after that time in the transport of passengers and mail, but horse-drawn vehicles on indifferent highways are too expensive a form of transport to assure wide-spread movement of freight. The improvement in passenger transport, however, provided an effective object lesson and assured a ready acceptance of canal and railroad building programmes, and particularly of the latter, when the steam locomotive, with its promise of more in the way of transport than had ever before been dreamt of, became a reality.

STANDARDS OF LIVING REVOLUTIONIZED

In England the railroads were utilized in an already well-settled country to accelerate commerce and to move persons and commodities which otherwise would not have moved — perhaps would not even have existed. In the United States the railroads went alongside, or even ahead of the pioneers, opening up great regions peopled only sparsely by savages and making available vast natural resources and agricultural lands which otherwise could not have been utilized to support and enrich mankind.

Henry Ford made the statement a few years ago that, "It is not strange, therefore, that transportation has almost wholly changed this country. The railroads built the country by making the exchange of products easy and convenient, but it remained for the automobile to break down all barriers, because a railroad can only follow its own tracks, while an automobile can go anywhere. The general standard of living has probably increased more rapidly within the past fifteen years than in all the years previous."

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[1] Kirkaldy and Evans, "History and Economics of Transport."

It is only sixty years since the connecting up of the Union Pacific and the Central Pacific Railways in 1869 first made it possible to cross the American continent by rail, and it was not until many years later that a second transcontinental rail route was made available. Rapidly and thoroughly, thereafter, the country was covered by a network of railroads which have permitted millions to live from the riches nature has afforded and to demand effectively the products which mass machine production in industry have made available.

Ocean transportation, connecting the continents, has likewise been revolutionized, as has also lake and inland waterway transport in its supplementary, though important, sphere.

NEW FORMS OF TRANSPORTATION

As OUR urban centres grew with the increasing industrial and commercial activity, it became necessary to provide facilities for the rapid transference of people within a city or community. The horse-car, when it was the best means known for providing this service, was widely adopted — only to give way later to the faster cable-car; which in turn was soon supplanted by the still faster electric trolley-car.

Surface and elevated city railways could not meet the demands of a great metropolis like New York, and so resort was had to the subways, with highly developed power and braking apparatus to permit high speeds with rapid acceleration and deceleration, so that the maximum number of trains could be moved and this expensive construction be used most intensively. It later became evident that there was another good reason for intensive use of the subways, viz., that it has been almost impossible to keep up with the demands for rapid transit caused by the growth of the metropolis. Other large cities have had a similar experience.

And then came the automobile. Where ocean transport may have some areas fifteen hundred miles away from it, inland waterways areas five hundred or more miles away, and railways habitable areas thirty or more miles removed, the automobile brings almost every square foot of habitable land within reach of an efficient transport medium. The automobile is essentially a supplement to other forms of transportation, filling in the vacant spaces between their routes. But in some instances it competes with them, providing not a new service but taking over functions formerly carried out by other transport agencies. This is evidenced by the scrapping of street railways in some communities and by the great inroads which automotive vehicles have made in the passenger traffic of the steam railroads.

The introduction of the automobile has brought a marvellous improvement in highway construction and extension and has thus greatly facilitated the exchange between and increased the productivity of outlying areas. More, it has enlarged the experience of millions of our people. It has knit isolated families into communities and removed the principal handicap of rural residence.

Now comes the airplane with its great speed, and to bring Chicago closer to New York than Philadelphia was a century ago. In some countries where the physical characteristics make the installation of other forms of transportation difficult or even impossible under present conditions, the airplane serves as a pioneer to open up and develop new territories. It provides a country without other modern means of transport with the same celerity of service which it can give in Europe or the United States. Days afoot, or on mule back, become minutes in the air.

PRESENT CONDITIONS AND TENDENCIES

We have been almost catapulted, as it were, into the very midst of this intense industrial age, with all its complications and complexities. We are going on at such a pace that before we can fully accustom ourselves to one set of conditions, we are faced with entirely new situations. We find ourselves, figuratively speaking, in an almost continual breathless state.

It may be well, at this point, to attempt to take a rough inventory of our present situation in the transportation world, or rather briefly to sum up the situation and note a few of the tendencies and difficulties which may help us to determine the general direction in which we are now headed.

RAILROADS

Two illustrations may be cited of the high regard in which the railroads of the United States are now held. The annual report of the Department of Commerce for the year 1926 contains a significant statement which includes these sentences:

> Probably the most outstanding single accomplishment since the war has been the reorganization of our American railways. . . The result of this great reorganization upon the whole economic fabric of the country has been far-reaching. Rapid dispatch has greatly reduced the inventories of the country, has contributed to stabilization of production and employment, and has increased the efficiency of all production and distribution.

Incidentally, had it not been for this greater stabilization of industry and the reduced inventories, rather than overproduction and large accumulations of surplus stocks and materials, the story following the financial panic of 1929 in Wall Street might have been a very different one — a story of wide-spread disaster.

Railroad officers and employees were surprised and delighted early in 1929 to see a full-page advertisement in some of the metropolitan dailies, entitled: "A New Year's Tribute to American Railroads by a Manufacturer *who has shared in their large contributions to national prosperity.*" It told how better railroad service had made it possible greatly to reduce inventories and then said:

> Throughout the nation hundreds of millions of dollars have thus been released from the necessity of financing goods in transit and storage, and diverted to productive enterprise. There is no doubt we have the improvement of railroad freight service to thank in very large part for this powerful impulse to the growth of national prosperity. . . Let it be known that their [the railroads'] accomplishments are already numbered among the finest traditions of American business, and among its most wholesome benefactions to public welfare.

This advertisement was inserted by the Simmons Company of St. Louis and reflects the attitude of manufacturers and shippers generally — a very different one from that which existed not so many years ago. When increased railroad efficiency, brought about by improved methods and equipment, releases to productive activity "hundreds of millions of dollars," then a substantial contribution to the general well-being has been made. Libraries, museums, operas, universities, and opportunities to live a larger life flow from such an increase of the national wealth.

With fewer units of equipment (cars and locomotives) and fewer employees than in 1920, the railroads of the United States are today handling a larger freight traffic, with no freight congestions, and are giving by far the best service they have ever rendered. Why?

We shall have space to give but a few answers typical of a multitude. Steady improvement has been made for many years in enlarging the capacity and improving the efficiency of the locomotives. Attention has also been focused since 1922 on maintaining the equipment in the very best possible condition. Wonders have been accomplished in the speeding up and the utilization of locomotives and in fuel economy.

The roadbed, track, and bridges, as well as the signalling apparatus, have been steadily improved to facilitate and reduce the cost of the movement of trains. Car retarders have been introduced to reduce the cost of and accelerate the operation of classification yards. Freight trains are not now broken up and remade at each division point, but are operated as a unit, over long distances, without even changing the locomotive. They spend a much higher percentage of time in motion than they did a few years ago. The slogan is "Keep the cars moving." Whereas formerly the greater part of new capital expenditures each year was for the purchase of new cars and locomotives, in recent years the situation has been reversed and the greater part of the capital expenditures has been for improvements to the roadway — reduction in gradients and curvature, additional running tracks, etc. To take care of increasing traffic the method has been, not to provide a proportionate number of new vehicles, but rather to spend money where it will speed up existing equipment and make it take over the additional load.

By dealing fairly and sympathetically with the employees, a spirit of co-operation has grown up and by similar treatment of the patrons their sympathetic interest has likewise been aroused. Shippers' regional advisory boards are now assisting the railroads to anticipate traffic changes or requirements, so that they may be fully prepared to meet unusual or seasonal demands. This is an economy for the railways and the shippers alike. It eliminates a needless industrial waste.

Electrification of steam railroads has been making slow but steady progress, being introduced in those places where for various reasons it promises to be most productive of economies. Twenty-five years ago some of the more enthusiastic electrical engineers predicted that the steam locomotive would be superseded in a few years. They did not realize, nor did the exponents of the advantages of the steam locomotive, the great possibilities which yet remained for increasing the efficiency and the capacity of the steam locomotive; nor did the most fore-sighted and optimistic railroader recognize the almost untold possibilities for utilizing the locomotives, wringing the mileage out of them as it were — and, incidentally, the limits in that direction have not been reached, by any means. Because of this and the effect of the World War on the finances of the railroads, the extension of electrification has been slower than was anticipated, but it is now making rapid progress where conditions are specially favorable for its use. It is interesting to speculate what may be accomplished in the way of increased speeds when some of our heavy traffic trunk line railroads are electrified.

Much could be said as to the introduction of special types of equipment, such as the rail motor-car, applications of the Diesel engine to locomotives, experiments with high pressure steam for locomotives, etc. Railroad managements have been keen in these recent years to take advantage of every opportunity to make better use of the equipment, facilities, and man-power, and we can look for continued and substantial progress in these directions as the engineers bring their improved methods and devices to perfection.

WATERWAYS

PROGRESS in marine transport has been characterized these many years by improvements in the design and construction of the ships, their motive power and other equipment, the net result being to lower the costs of operation and to speed up the movement of traffic. Ocean-going freight ships, for instance, have been increased in size and capacity and the better classes of such vessels, instead of travelling at 9 or 10 knots, as they did a few years ago, now make 14 or 15 knots. Passenger vessels are larger and more commodious and luxurious, and have been accelerated, comparatively, even more than the freight ships. It is economy, not lack of engineering competence, that prevents even greater reduction in the time consumed in crossing the Atlantic.

A shortcoming, particularly in American ports, which must be met and overcome with determination and promptness, is the inadequacy of the loading and unloading equipment and facilities. While we cannot expect, with a general or mixed cargo, to approximate the wonderful coal and ore loading and unloading facilities for handling this specific traffic on the Great Lakes, much — very much — remains to be done in improving these facilities at all ports — ocean and inland waterway. Improvements in this respect may do much to strengthen the position of the waterways in their competition with other forms of transportation.

MOTOR BUSES AND TRUCKS

Much must yet be done to improve and adapt motor buses and trucks to specific types of service. The early buses, and they were built not so very long ago, were comparatively crude and not particularly comfortable. Considerable progress has been made in overcoming these handicaps, but the practical experience of bus operation is clearly indicating lines along which improvements must yet be made better to meet the needs and convenience of travellers who use its various types of service. The public also demands the same adequacy and reliability of service from motor buses and trucks that characterizes railroad travel.

With the rapidly growing travel on roads and streets and the ever-increasing number of automobiles, steps must be taken to improve the safety of operation, and this suggests much more severe regulations as to the examination and qualifications for drivers. The automotive vehicle in the hands of an incompetent operator is a potential instrument of death. Yet, even in those states where operators are licensed, a few hours' experience is all that is required of a driver. Contrast this with the railroad. A man, to sit at the throttle of even a freight locomotive, must have had from five to ten years' service as a fireman. There are few men driving passenger locomotives who have not at least twenty years to their credit. These men not only know their machine, but they also know intimately every foot of the route over which they travel. To this fact probably may in large measure be ascribed the enviable record for safety made by the railroads.

Congested traffic conditions in some sections of the country indicate the need of special highways for motor bus and truck traffic in the interests of safety, as well as of greater speed and operating efficiency.

AVIATION

It is doubtful whether the general public has any appreciation of the extent to which commercial aviation has advanced in the past year or two. The carrying of mails alone has been no mean contribution to our economic, social, and political life. The carrying of other merchandise and passengers is steadily and rapidly increasing. This form of transportation is truly in its infancy and yet it is already in a fair way to establish a strong position for itself in the field of high-speed travel.

Greater safety and reliability must still be achieved, but every day marks progress in this respect; this is forcefully brought home to us when we check back a year or two, or three, and note the rate at which we are moving in these respects.

It would seem that the real problem of present-day aviation is the perfection of a safe, personal airplane which will not only allow people to fly it, but will have far more value in its psychological effect upon the general public in convincing a generation, which is either consciously or subconsciously afraid to get off the ground, that flying is safe. When this is done, there will probably be a largely increased demand for air transportation as afforded both by transport companies and by private flying. The real problem today is thus basically a design-engineering problem.

It is necessary to check up and maintain the condition of aircraft far more carefully than any other type of travel conveyance. This suggests the engineering problem of developing craft which are simpler in power plant and structure, so that the high quality of inspection and maintenance now necessary, which add so greatly to the expense of service and equipment, will not be required in the future.

There are those who still insist that the force of gravity cannot be conquered, but without attempting to minimize the difficulty, it may be stated with some degree of confidence that engineers are in a fair way to overcome it, so far as stability and safety of aircraft operation is concerned. It is doubtful, however, whether in achieving this ideal the aircraft of a few years hence will look anything like the present equipment.

GENERAL

THE INTRODUCTION of new forms of transportation, or the marked improvement of existing forms, if they are reflected in lower costs, or better, faster, or more reliable service, are usually accompanied by profound economic changes which may seriously affect commercial, social, or political relationships.

The introduction of the automobile, the building of the Panama Canal, the coming of commercial aviation, are instances of events in the transportation world which have greatly changed the outlook of various interests in different localities. New economic forces are set up which may bring about wide-spread and powerful reactions. Millions invested in good faith under older conditions may be menaced. The problem of attempting to foresee these conditions and to control the situations so that disaster may not visit certain interests in the community, or even whole communities or regions, while the necessary readjustments are being made, is not unlike that which must be met in our industrial and commercial operations and consolidations.

ESSENTIALLY A PUBLIC SERVICE

SINCE the railroads traverse great areas and connect widely separated communities, and because their regular and continued functioning is fundamental and vital to the welfare of a community or state, they are regarded in the light of public servants and so have either come into the hands of their respective governments, or, if privately owned and operated, have been subjected to close governmental control or regulation. Their strategic importance in warfare has also been an important factor in this process in many countries. The same thing is true, at least in some degree, of other types of transportation.

Politics and political expediency have entered too largely into matters of control and regulation of our transportation systems, and particularly of the railroads, and one of the great problems confronting us today — in most, if not all countries — is how to place such control and regulation on an economic and scientific basis.

The United States presents an excellent example of private ownership and operation under governmental regulation. True, the regulation has not always been wise. Good politics has seldom been synonymous with good railroading. Offsetting this, however, strong and capable administrative railroad organizations, supported by engineering intelligence and by capital to make this intelligence effective, have made possible a continued improvement under conditions which have frequently been very adverse, so that today the railroads are most highly and generally commended because of the excellent character of their service. They are operating, however, under a serious economic handicap, one which may bring disaster if it is allowed to continue too long, namely, the low average return they have been permitted to earn on a conservative valuation. The railroads, it must be remembered, have to compete for capital in the same market with industrial concerns which are limited as to their profits only by the ingenuity of their executives.

As one move in the right direction, ought not the various regulating bodies to have included in their membership men of engineering and business ability ? Who, for instance, ever heard of a competent engineer or industrial leader on the Interstate Commerce Commission? Yet such men operate our great transportation enterprises. Is the type of mind required to regulate them so different?

In suggesting the use of the engineer as an aid to the working out of the transportation problem in its larger aspects, I have in mind a very remarkable presidential address made before the American Society of Mechanical Engineers in 1923 by John Lyle Harrington on "The Engineer, His Abilities and His Public Obligations." In it he made this statement:

> But in the broad study of industry as a whole as it affects the nation and the world, the engineer should have an important part. He should contribute largely to the solution of the problems of the equalization of industry; of preventing inflations and depressions, for they are complementary; of encouraging development in lines in which competent investigation shows it will be rewarded; of retarding those lines which show a tendency to excessive development. This can best be done by a thorough analysis of the factors entering into the problem and publishing the results to the world. The profession should resolve itself into a fact-finding and publishing organization in all matters pertaining to the industry with which it is associated.

The engineer, thus defined, is simply a man who by training and experience is capable of dealing realistically with the complex details of modern industrial civilization.

TRANSPORTATION AS A WHOLE

The maximum in national well-being requires that type of transportation service, or a combination of those types of service, which, all things considered, will give the quickest and most reliable service for the lowest possible cost. The nature of some commodities is such that rapid transport is not necessary; others must be rushed at high speed. Some passengers prefer — or economic conditions make it desirable — to travel slowly; others desire to go faster; and still others must go at top speed, either because of business, or emergency, or because they have ample means and prefer so to do.

We have as yet failed to recognize the necessity of viewing the transportation problem as a whole. The overlapping of the various agencies of transport gives rise to a serious problem. When two or more agencies offer their services for a particular transportation task, certainly there is one of them which can do it better than the others. Which is it? The solution cannot safely rest with the politicians, or even statesmen, but rather must be based upon careful study made by qualified experts and on sound business and engineering principles.

What agencies of transport have we to consider? The private automobile; the motor bus; the motor truck; the street-car; the inter-urban electric lines; ocean, lake, river, and canal waterways; the railroads; and the airplane and airship — all have a place in the picture.

Unlike the railroads and the street and inter-urban lines, however, the other forms of transportation are given governmental assistance in some form or other. The cost of this taxpayers' contribution should be considered in connexion with the direct charges to customers for the service, to make governmentally assisted transport agencies comparable with those which pay their own way unassisted. The railroads and the inter-urban lines must provide and maintain their own right-of-way and pay heavy taxes upon it, and these taxes have been rising at a rapid rate in recent years.

Railroad rates are regulated by the Interstate Commerce Commission; the railroads must submit to a great variety of regulations imposed by federal, state, and municipal governments; they have little control over wages. On the other hand the highways, waterways, and airways are established, maintained, and policed by the governments and municipalities. The traveller or the shipper thinks largely in terms of the direct charges for transportation, i.e., covering the operation of the carrier and nothing more, and little or nothing of the indirect costs. It is as if railway tracks were furnished by the government and all the transport companies would have to provide would be the cars and locomotives and men to operate them. Manifestly if they had only these expenses to meet they could transport freight and passengers at rates much lower than they now are forced to charge.

It would seem that all these common carriers should be placed upon the same basis, so that the public can determine with some degree of accuracy which system of transportation, or which combination of systems, will best serve its purposes. Some such plan is necessary to the general well-being — not to protect any one form of transportation, but to assure that each transportation task be performed by the agency best fitted, all costs considered, to do it. Traffic moves on the route of least resistance. The only way to assure that it moves in the most economical manner is to make rates reflect total costs. The trained business man, the engineering expert, and the economist should be drafted for service in helping to solve the problem, which is probably the most serious one that will be encountered in transportation today.

A considerable group is fast coming to the conclusion that all these forms of transportation should be united under one direction, so that, for instance, instead of having railroad companies, or motor bus organizations, or waterway or airway companies competing with each other, we will have transportation companies serving different regions or sections and so co-ordinating the various types of transportation that they will in effect function as a single unit.

This may almost automatically assist in solving another troublesome problem and bring about a much needed improvement — that of store-door or house delivery of goods shipped by rail or other means. It will also direct each form of transportation into that field of activity to which it is best suited and where it will satisfactorily perform the type of service required at the lowest possible cost, all things considered.

This would seem to be the next big step directly before us and it is not altogether improbable that its accomplishment will assist considerably in relieving the pressing traffic conditions on the streets and highways of some of our more congested centres. Certainly we cannot continue to go forward blindly when a businesslike and scientific approach to the problem offers such certainty of favorable result.

TRANSPORTATION WITHIN INDUSTRIAL PLANTS

We must not overlook, although it may appear incidental to this discussion, and particularly at this place, that one of the largest contributions of the engineer to modern industry and mass production has been the development and installing of material handling systems and apparatus in industrial plants of all kinds and descriptions — from the canning of peas to the manufacture of automobiles or the operation of a mine. The importance of this form of transportation in relieving the worker of heavy manual tasks and in speeding up production, and thus greatly reducing the unit costs, will not likely be over-estimated. By its use raw material entering one end of the plant travels steadily and speedily along and comes out of the far end, a finished product ready for use.

Here we find to an unusual degree the co-ordination of different types and classes of conveying apparatus and machinery, which is possibly a promise of what may be accomplished eventually in co-ordinating the various forms of transportation used in a community, a region, or in the nation at large. In some instances, indeed, as in large mining operations, the intra-plant operations are co-ordinated with extensive rail and waterway transportation systems.

DISTRIBUTION OF POPULATION

WITH the flow of population to the cities and the building up of great industrial and commercial centres, we find millions of our people living in congested districts with plenty of desirable land not far distant; moreover, the average worker in the larger cities must spend too great a proportion of his time going to and from work. How can the population be distributed more evenly to prevent such congestion and reduce the amount of time uselessly spent shuttling back and forth (as much as two or three hours or more a day in many instances) ?

Henry Ford has boldly tackled the problem in locating his new plants. Other experiments are being made, but, in the main, the problem has as yet hardly been scratched on the surface. Its solution must rest largely with the engineers and among them should be included those who have specialized in transportation. While it is true that modern high-speed transportation has made possible great congested cities, it is not mainly responsible for them. There were horribly congested cities long before the railways. Cannot scientifically organized networks of transportation, in conjunction with other measures, make possible a decentralization of industry and scatter our population more widely over areas with grass, sunlight, and park land?

A still broader problem of population for which our improved transportation and communication is responsible was recently pointed out by Dr. T. N. Carver, of the department of economics at Harvard, in commenting in an article in *Airway Age* on the growth of aviation and the accomplishments of the Wright brothers: "It is true," he said, "that these superior means of transportation and communication are making near neighbors of us all. But even near neighbors have their problems, especially if they have different standards of living. If they have widely different standards, the nearer they live together, the more occasions of misunderstanding and irritation there are likely to be. There is greater need of a mutual regard for line fences.

"To be more specific, a country with a standard of living noticeably higher than that of the rest of the world, has only one possible way of maintaining that lead. That is, to prevent the swarms of low-standard inhabitants of the rest of the world from coming in and eating its people out of house and home. When the low standard did not know about conditions in the favored country, when distances were difficult to overcome, this danger of a peaceful invasion of low-standard populations was not very great. It becomes imminent when the information spreads and when distances are easily covered. There is then no natural protection for the standard of living. It must be protected either by international agreement or by insistence of the nation with the high standard of living; otherwise the lowest standards of living to be found anywhere in the world will force the whole world down to their level."

Here, too, is a challenge for the engineers whose achievements have made these conditions possible. It is quite possible that Doctor Carver has overestimated the dangers which may arise from jealousy, for if you get close enough to a neighbor to admire his style of living, you are quite likely also to learn *how* he does it. The substitution of the realistic and scientific method which the engineer uses for a cruder and more primitive psychology will make riches displace poverty in many other places than North America alone.

But can the conscientious engineer escape the necessity of consecrating himself more fully to mankind in order to assist in the wise control and direction of the forces which his efforts have set in motion, even though he may not have foreseen these forces when he inaugurated his new schemes ?

May it not have been with some realization of this responsibility that Herbert Hoover established the Federated American Engineering Societies, now known as the American Engineering Council, one of the chief objectives of which is to "*further the public welfare* wherever technical knowledge and engineering experience are involved" ?

WHAT OF THE FUTURE ?

It would be foolish today to attempt to predict what types of transportation will be in use a century from now. We do know with more or less assurance that the character and appearance of the conveyances will be very unlike those of the present day, if for no other reason than that tendencies already becoming evident indicate more or less radical departures from some of the present designs. We smile indulgently at pictures of types of transportation used by our fathers and grandfathers. Our great-grandchildren will probably have quite a laugh when they look back upon the antiquated equipment used in this day and generation. They will travel more cheaply, with greater convenience, and at a lower relative cost than we do today.

Proud as we are of our accomplishments in aviation, for instance, the art is still in its infancy. The airships and airplanes of today will be superseded — and probably in the not distant future — by differently designed and far safer equipment which can better cope with the force of gravity and the various detrimental elements involved in air transportation.

If one were to venture upon predictions concerning the future, he would first have to remove all brakes on his imagination, and then possibly take something to stimulate it far beyond its normal functioning. Leonardo da Vinci, the great artist-engineer, was regarded as crazy and, figuratively speaking, as "flying in the face of Providence" when he attempted to build a flying machine. Note his prediction in the early part of the sixteenth century: "The human bird shall take his first flight, filling the world with amazement, all writings with his fame, and bringing eternal glory to the nest whence he sprang."

Jules Verne amused his readers with his startling and seemingly impossible stories. They still make good reading, but the actual facts and accomplishments of today dwarf his imagination. His "Cinq Semaines en Ballon" (Five Weeks in a Balloon) was written in 1862; "Vingt Mille Lieues Sous les Mers" (Twenty Thousand Leagues Under the Sea) in 1869, and "Voyage Autour du Monde en Quatre-vingts Jours" (Voyage Around the World in Eighty Days) in 1872.

An engineer — an important officer of one of our leading national engineering societies — relates that when he was a youngster, forty-five years ago, he and his companions used to get great enjoyment from the highly imaginative stories in a weekly story paper, the reading of which was forbidden by their parents. He still remembers some of the more fantastic of these — such as "Franke Reade, Jr., and His Iron Man of the Prairies" and "Franke Reade, Jr., and His Queen Clipper of the Clouds" — and if he remembers rightly after these many years, they were but crude prophecies which are not at all extravagant today in light of the mechanization of the farm with its tractors and other machinery; or, in the latter case, of the present-day dirigible.

The engineer, although he may not have been known or recognized as such in the early days, particularly for the more simple and primitive applications, has been largely responsible for the development of all forms of transportation. Engineering ability is required to discover, install, operate, and maintain any form of transportation equipment. Moreover, the continuous application of engineering skill is required to keep the transportation plant and the methods of operation in step with the growing and changing requirements.

It may be well to pause here a moment to inquire what an engineer is. Many people have visioned him as a mathematician or a calculator, or as a draftsman or designer, or as some sort of a "high-brow" expert. Well, there are engineers and engineers! One of them, and admittedly he is an exceptional one, is now functioning as the Chief Executive of these United States. And, strange as it may seem, the First Lady of the Land received an engineering training also.

There is the inventor and the research type of engineer, but there is also the engineer of the administrative type who can direct great engineering enterprises and who understands the handling of human forces as well as the control and utilization of materials and natural forces. All of these types function in their proper places in transport.

Since the engineer will be largely responsible for the further development and progress of transportation methods, and because he must match his imagination against the cold facts of every-day life and the standards of intelligence of those who will make use of the products of his imagination, he has certain very definite restrictions upon giving free reign to his fancy, and is, therefore, possibly inclined to be ultra-conservative in making his prognostications. The imaginings of the fictionist are not thus hampered. The inventions or discoveries of the engineer and scientist will not be used until they can be so presented, or the public is so educated, that they will appeal to the public with sufficient force to make a market for the innovation. The engineer, because of the effect of these limitations, can well leave the task of making predictions for the future to the writer of fiction.

This much we can say, however. The contributions of the scientist and engineer (and they promise to continue to be very great) will make for a better utilization of our materials and resources — natural and human. They will increase and cheapen production and will add to the comfort, convenience, and enjoyment of life. And because the engineer is coming to a larger conception of his responsibilities to public welfare and public service, he promises to be a not unimportant factor in the working out of a more even and equitable distribution of the good things of life to mankind generally.

Dean Dexter S. Kimball, in his presidential address before the American Society of Mechanical Engineers in 1922, squarely presented the challenge in these words:

> . . . It is undoubtedly true that if he [the engineer] will direct his energies to the problem of the distribution of wealth as earnestly as he has devoted them to its production, he can make a contribution to industrial economics that will be exceedingly helpful. The engineer, and he alone, has a direct and personal knowledge of the great industrial machine that he has created. Until recently he has intrusted the operation of this machine to others who often knew little about its refined mechanism. It is high time that he took charge and operated the complicated mechanism himself.

The engineer must also share the responsibility of helping to educate the public to use properly the results which follow the introduction of his discoveries, inventions, and methods — results, such as more leisure, greater wealth, etc. If he does not do this he may in fact have created a "Frankenstein."

I can almost see the surprised and pained look on the faces of some of those who read the above paragraphs. "What foolishness," you remark, "your imagination is running riot. The average engineer is a plain matter-of-fact chap, with no such 'high-faluting' ideas. Responsibility for his fellows? Why, he is so busy earning a living, bringing up a family, and looking after his own affairs that he is not worrying over the welfare of anyone else."

Quite true, in too many cases. Nevertheless, a steadily growing number of engineers are developing real professional consciousness and are subscribing to high ideals similar to those of John Lyle Harrington and Dean Dexter S. Kimball, who have been quoted in this chapter, and who are representative of a host of others in the engineering world.

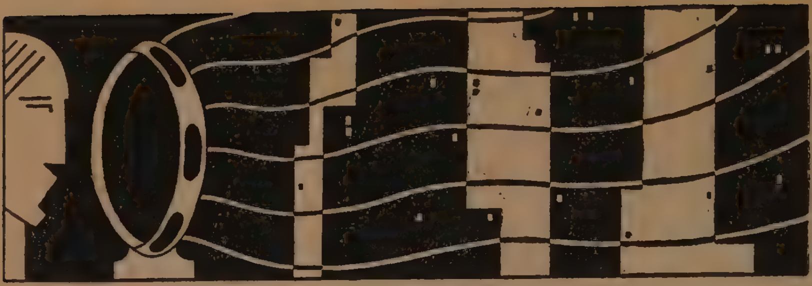
MORE ABUNDANT LIFE

AND HERE let it be said that scientists and engineers are not a cold-blooded set of mathematicians and calculators. The intimate association of many of them with the forces of life and nature has, if anything, possibly tended to strengthen their spiritual insight.

The Man of Galilee spoke many parables and left us a rich heritage of spiritual truths. But he also had compassion on the lame and halt, and the blind, the hungry and the suffering, and did what he could to feed, comfort, and cure them.

We read that he said, "I came that they may have life, and may have it abundantly." Possibly he felt, as does that practical man of God in India, Sam Higginbottom, that man's spiritual strength cannot thrive if he is starving and destitute. At any rate, without detracting in any way from the spiritual significance of this statement, we can recognize that it may apply also to man's material needs. The scientist and engineer have been and always will be important factors in devising means whereby man — all men — can enjoy a higher degree of health, leisure, and material prosperity.

Is it too much to expect that the engineer, as he becomes more alive to his responsibilities in public life, will become a more aggressive and constructive factor in seeing that the material prosperity made possible by his activities will be rightly used and directed? And are not those engaged in transportation, because it is so essentially a public service and so fundamental and vital to modern civilization, particularly equipped to be helpful in the larger aspects of the engineers' contribution to human welfare and progress — material and spiritual?



VI — COMMUNICATION

By Lee de Forest

THROUGHOUT the slow and patient course of human evolution from the pre-anthropoid to modern man no other single development has wrought so marked an advance in civilization as the acquired ability of one mind to communicate with another, first directly and then through innumerable agencies devised by inventors.

When vocal sounds first became articulate the ancestor of man leaped suddenly from the dumb shackles of the brute. The discovery of that astounding faculty lashed the dull unfolding brain of the race into swift expansion. This faculty of communication therefore, more than any other, has contributed to the rapid progress of the human race. With the animal man, as distinguished from other higher forms of life, the poet says, "the deed produced the word." And it is equally true that the word by stimulating the mind led to new deeds and new ideas, endlessly evolving together.

From the hour when distinct and differing vocal sounds became associated with definite acts, definite states of facts or situations, the growth of the human brain begins to attain a complexity, a refinement, which qualifies it to be defined as human. There then began reflection, introspection, classification of ideas. With communication between men began that *acceleration* of progress, replacing the slothful *drag* of mental evolution. And thereby, and by this alone, has the race been enabled to achieve in some scant hundred thousand years more progress from the pit of savagery and the mire of ignorance than was witnessed by the hundred millions of years after the first mammalian crawled on four feet.

Thus was communication the foundation of the first primitive civilization. It has been the foundation of every civilization in man's history. As its machinery became more complex, more intricate, more systematized, so we find the civilization which it represented, nay, which it engendered, also more complex, more refined, more beneficent. The ability to exchange thoughts quickly and accurately determined the degree and the extent of that civilization.

With a simple series of grunts and signs, the prehistoric tree or cave man was limited in his social contacts to his mate and his offspring. With the dawn of a rudimentary spoken language, the social unit became the tribe, with the campfire as its centre. The body politic, as some sage has expressed it, has always been limited by the number of listeners who can be reached by one man's voice.

The first crude sign writing, whereby thoughts might be recorded, helped to bring scattered men and tribes into the social unit, and even established contact with future generations through the permanency of the written word. With the development of the spoken and the written word, civilization rapidly swept along through the early ages and up through mediæval times, even though ecclesiastics maintained a monopoly of writing and reading. Then came movable types and the printing-press of Gutenberg, with the Renaissance or rebirth of civilization. Reading and writing became a common heritage. Civilized peoples were welded into individual nations. The postal service followed in due course, crude and rudimentary at first, fostering a moderate exchange of thoughts between people. It is said that the ancient Greeks, and possibly before them the Persians, developed a crude method of military signalling by heliograph. Then flags by day and fires by night contrived to convey information and command over wide distances and instantly. These and the elaborate system of semaphore signalling devised during the French Revolution by Claude Chappe blazed the path leading to the electric telegraph of Morse.

Before the nineteenth century was half over the first telegraph made its bow, serving as an instantaneous means of communication over great land distances, to be followed shortly by the submarine cable for spanning the oceans. An experiment with a new form of telegraphy gave birth quite unexpectedly to the telephone, whereby business and social life could be immeasurably increased in tempo.

Early in the twentieth century wireless telegraphy made its bow, at first as a means of spinning communication threads between ships and shores, thereby robbing the sea of its hitherto *sinister silence*, and later as a practical means of transoceanic communication. And then came the "Aladdin's lamp," commonly known as the vacuum tube, whereby electricity might be developed into a veritable acrobat to perform no end of amazing tricks at the command of man. Transoceanic and transcontinental telephony followed in due course. The electric voice, capable of reaching an unlimited audience, was soon placed at the disposal of the leaders of mankind. And finally radio broadcasting became an integral part of modern life as an organized means of mass communication, in epochal contrast with the former private or individual communication idea, promising to weld the citizenry of a country into a solid, homogeneous, and thoroughly informed nation; and subsequently, by an exchange of radio programmes, to lead to the creation of a truly international state with all peoples enjoying the fruits of real understanding. And finally a lasting universal peace.

Thus we arrive at the present day in the scheme of communications, which we are asked to appraise on the basis of its meaning to present and future civilization.

THE SHRINKING WORLD

THE main purpose of our present-day communication systems is to bring all peoples into closer relations for business, social, and political purposes. To this end we have in use upwards of 6,500,000 miles of telegraph wire now strewn from one end of the world to the other, as well as some 265,000 miles of submarine cable to extend our telegraph communication systems across the oceans.

The main essentials of a communication system are speed and accuracy, followed by the lowest possible cost. Civilization in the past has been seriously affected by the slowness of communication facilities. A classic example is the Battle of New Orleans which made Andrew Jackson famous but which took place ten days after the signing of the treaty of peace at Ghent by the British and American Governments. It required many weeks for the soldiers in the United States to learn that peace had been signed and hostilities were legally at an end. Today the signing of a peace could be flashed around the world in less than a second. Everything today is aimed at speedy communication. Every part of the civilized world can be reached within minutes and in most instances within seconds. Today a telegraph signal can be sent seven times around the world in one second!

TELEGRAPHIC CORRESPONDENCE

THE original purpose of the telegraph was to send essential messages in minimum time between distant points. For decades the telegraph was limited to vital business correspondence, telegrams dealing with deaths, marriages, arrivals, and the like, events of an extraordinary interest. It was not many years ago, and is still the case in rural communities, that receipt of a telegram was a dire event, foreboding evil news, to be opened with fear and dread. But today communication engineers are rapidly making of the telegraph service a benign instrument for well-wishing, for greetings, for an infinity of social and business purposes. Today the telegraph service is being steadily developed toward the time when there will be comparatively few written business messages between individuals and parties.

To this end engineers have been striving for greater speed and consequently lower operating costs, to be reflected by lower rates. Today the telegram is no longer a luxury. It is a necessity in social and business life. Special low rates have brought the telegraph letter into popular favor, whereby a message comparable to the usual letter in length and in explicit details is feasible. Deferred telegram rates have also made lengthy telegrams popular. "Don't Write — Telegraph!" has become a slogan of business and of many of us in social life.

Who can compute the sum total of added wealth, by economies effected, by disaster circumvented, by crimes prevented, or criminals apprehended, what lives saved, as a result of the telegraph?

The inventors and engineers who have through the past half century brought about this universality of the telegraph have done far more than merely wrap wire around the globe, as though it were a ball of yarn. They have tied together by bonds far stronger than this copper and steel the scattered individuals and widely separated peoples, nations, races of the world.

Lowered rates have been made possible by more intensive use of the telegraph lines. More traffic is passing over given wires day by day. The telegraph key and sounder, which held sway for decades, have made way for the automatic sender and receiver. To-day much of the traffic over long lines is handled by the telegraph typewriter and girl operatives. Messages are typed in much the same way as a usual letter and are reproduced by an automatic typewriter at the destination. The trend is toward still greater speed in the future, so as to make telegraphy even more popular with the masses.

Tighter and more taut stretches this ever-increasing web of wires, drawing into ever closer contact peoples the most widely separated, by distance, by racial distrust, by misunderstanding, and lack of mutual acquaintanceship. Such inventors and builders are continually harnessing together at first unwilling teammates, teaching them, subtly, unconsciously, the lesson of strength by union, salvation by understanding and co-operation. And thus this potent instrumentality, the wire telegraph and cable, perhaps first serving most earnestly the needs of war, has become a prime minister for peace. It is this quality which characterizes all types and modes of communication, regardless of the machinery employed, the newspaper, the post, the wire telegraph, the telephone, and finally the radio — this quality for breaking down the age-old barriers of separation, unknowledge, misunderstanding, and mistrust, which makes man's progress in communication his most promising evangel for peace. And by the same reasoning the communication engineer, even though he rushes wires over battlefields and rigs radio from airplanes and front-line trenches, is despite himself the most potent apostle of peace.

Let military engineers devise new and more powerful artillery, bombing planes for their "next war"; or the chemist new and concentrated hells of toxic gases capable of asphyxiating entire cities.

The communication engineer is the while making known these secrets to the world, and at the same time bringing slowly but surely, though perhaps unwittingly, a mutual understanding among nationalities which shall confine these destructive devices to the proving grounds and the laboratory.

When Bell first transmitted the human voice over a wire, electric signalling or establishing understanding at a distance made a gigantic stride in advance. The tongue spoke instead of the finger. It was as though the signalling dumb had suddenly learned to speak aloud. Too much emphasis cannot be laid on the significance of this achievement. Bell's first telephonic words were sibyllic: "Watson, come here, I want you." The mission of the telephone was there epitomized: "Come here"—a distant stranger draws closer. "I want you"—man *needs* his fellowman, and the telephoned word is immeasurably more eloquent to express this need than was the Morse Code. If the reader would realize this let him tune his radio to one of the longer wave broadcasters, like WEAF, and hear the occasional raucous rasping noise of the Navy Station crowding out some sweet musical number, or a mellow voice.

THE TELEPHONE

NO GREATER influence has been at work in moulding our civilization than the telephone. Today we have some 26,000,000 telephones installed throughout the world, connected by some 70,000,000 miles of wire. No longer do we have to go out to meet our party. Instead, we phone. Our concentrated business and social life of today is built around this telephone. It has been estimated that if all conversation in business and social life had to be made in person, without the aid of the telephone, we would have to spread out our cities to several times their present size, so as to accommodate the enormous flow of persons and messengers going back and forth through our streets and halls and elevators.

This phase of the telephone engineer's work is not wholly to the credit side of our urban civilization. For anything which facilitates this mad piling up of steel and masonry, thus stupidly and viciously aiding in the poisonous massing of human sufferers in subways and noxious streets, is most certainly destructive of human health and well-being. It is deplorably retrogressive.

Yet without telephone service for a day modern business would be paralysed and the social life suffer a severe blow. Who having once used the long-distance telephone — say from New York to San Francisco — can fail to be thrilled at the realization of what communication engineering has accomplished in facilitating trade and friendship, annihilating earthly time and space? The actual poetry of this engineering triumph was brought stunningly upon me when at the Panama Pacific Exposition I sat in an audience in San Francisco and heard the breaking of the surf upon the far Atlantic shore. There our modern sophisticated generation was enabled truly to appreciate for the first time the deep significance of that historic phrase, first signalled over Morse's wire: "What hath God wrought"! Not the least impressive were such considerations to me, who two years previously had given to the Bell engineers the amplifier tube, destined so soon to make possible their long-cherished dream of the transcontinental telephone.

WIRELESS TELEGRAPH

THERE is an infinity of places where wires cannot be strung — either physically or economically. Take the ship at sea for instance. Today's miracle of the radio is not unlike the myth of that Greek hero who went forth into the Labyrinth to slay the Minotaur, and who, in order not to become lost as had been the case with his unfortunate predecessors, paid out an unbreakable thread as he advanced through the winding passages in search of his prey. It is much the same with the ship equipped with radio; there is a constant thread of communication between its crew and the distant shore, as well as with other ships. Marine radio was the first and the most logical development for wireless telegraphy, since it filled a crying need. Later came transoceanic wireless, beginning with Marconi's classic experiment in 1901, when the letter S of the Morse Code was, we are told, flashed across the Atlantic from Cornwall in England to St. John's, Newfoundland. Actual progress was slow, due to the technical obstacles in a new and unknown realm. In 1908 a commercial transatlantic wireless service between Glace Bay, Nova Scotia, and Clifden, Ireland, was opened to the public. This service was most uncertain, due to severe static interference during at least six months of the year. It remained for the World War to bring about research and engineering achievements of a very high order, which resulted among other things in the development of the Alexanderson high-frequency alternator, which spanned the thousands of miles of ocean in a practical, reliable, and economic manner for true transoceanic radio service.

WORLD-WIDE RADIO SERVICE

For years there was every indication that radio would be employed mainly for military purposes. Prior to the World War Great Britain, France, and Germany had ambitious military wireless plans, which included high-power radio stations at various points in their colonial possessions, so as to cover not only their territories but many other countries as well. Due to the imperfect state of the art, however, these plans were quite impossible of fulfilment at the time.

More recently the vacuum tube transmitter principle discovered by the writer in 1912 was developed to a highly practical point, particularly for short waves. Today, for the investment of no more than was formerly required for a single Alexanderson alternator installation, it is possible to install twenty-five to thirty short-wave radio transmitters, each capable of handling four or six times as much traffic as an alternator circuit. The great saving in first cost and in maintenance has made possible the inauguration of such circuits in many of the smaller countries which, economically, could never have been connected to the United States by means of an alternator installation.

The American World-Wide Radio Service has in truth no military motives. It is intended to bring about a free exchange of commercial, social, and diplomatic correspondence between scattered peoples. Yet it is a service quite free from the hazards of wires and cables in time of war since there is no physical conductor to be severed. The little nation, even without access to the sea, now has radio service direct with many countries. It is the freedom of communication idea made real.

Every effort is being made by the radio engineer today to speed up transoceanic radio service. Automatic transmitters, worked like a typewriter, turn out a perforated paper tape which forms the dots and dashes for the radio transmitter. At the receiving end, a moving paper tape with a wavy ink line flashes past the operator seated at his typewriter, who pounds out the words which he translates from the hills and peaks of the wavy line. The British-owned cable system of world-wide proportions has had five decades or more in which to reach its present proportions. Transoceanic radio, as we know it today, has been developed in less than a decade. And the competition of radio has brought about a steady reduction in rates. Deferred radiograms, radiogram letters, and other special forms have popularized this means of communication.

The transatlantic telephone by radio has now become as well established, almost as popularly known, as is the wireless telegraph. It is useless to catalogue the foreign capitals now in reach of the voice of any telephone subscriber in America. For before this volume is off the press this list would be most incomplete.

It is exceedingly interesting however to point out that while wireless has run the submarine telegraph cable a merry race for the past two decades, has more than held its own in competition, and has brought about a reduction in tolls — that while the transoceanic telephone was originally impossible except by radio — now at last the tide has turned. "Old Man Static" and "Father Fading" have too long interfered with radio service. Potential earnings of transcontinental and international telephone service have become so convincingly demonstrated that what had always been deemed financially, if not engineeringly, impossible has at last been achieved.

An improved telephone cable has been perfected by engineers of the Bell Laboratories and will be in operation for transatlantic communication possibly by the date this book is issued. "With the aid of these cables, which will practically relegate static to the scrapheap," said one of the executives of the Bell System recently, "the entire field of transatlantic cable communication will be revolutionized. It is no exaggeration to predict that within a few years telephone communication with every foreign country on earth and intercommunication between these countries will be a reality."

THE TELEPHOTO AND PHOTORADIOGRAM

STILL looking ahead toward new goals, radio engineers have been working on facsimile transmission, whereby typewritten or handwritten messages themselves may be flashed through space. Marked progress has been made. Today photographs, drawings, finger prints, printed matter, handwritten and typewritten messages, and business and legal documents are flashed across continent and ocean. Legal documents, sent by electricity across the sea in facsimile form, are now accepted at their face value. Likewise commercial papers. Thus a new day dawns for business, when the business man in New York can sign his name to a document in Japan or Berlin within an hour.

Outstanding, beyond all compare, as a vivid example of the wonders which modern radio has achieved in the progress of communication is the reporting to a breathlessly awaiting world of the recent flight over the South Pole by Commander Richard Byrd. In that event shines epitomized all the wonder, all the thrilling romance with which radio has endowed and adorned science. Nothing has more grippingly appealed to the popular imagination, now somewhat stabilized and based on foundations of fact, than this reality. There at the uttermost nadir of the world was an intrepid hero of exploration, with a devoted band, carefully educated and trained for the task, equipped with the latest implements which the sciences of navigation and aviation have contrived, profiting from all that the hard experience of a century of polar exploration could teach, in the very act of epochal flight over bleak abysses, scaling forbidding barriers of unimaginable mountains of ice. And by virtue of radio communication the runners of Byrd's plane had scarcely touched the snows at his base station before the presses of the entire world were detailing this latest triumph of man over matter.

It was not history we were reading. It was not as when, only twenty years ago, Peary came out of the North to file his first dispatches five months after he had reached the Pole. Nor when for three anxious years following 1910 the outside world knew not whether Scott's brave party was alive or dead. Not history this, but a gripping present reality of adventure and romance. It is not too much to classify the achievement of Byrd and his associates with radio communication, especially during this South Polar flight, as the most astounding example in the history of the art of transferring intelligence.

Where it is leading no one can surely tell. Radio of the future can only be guessed at with extreme caution, but we know that it will be forever indispensable to the gatherer of news.

The explorer now knows that the world may follow him, intimately almost, if radio is employed. It cheers him to accomplish the utmost in the limited length of time the party can survive beyond the borders of civilization. Constant use of radio by Byrd since his party went south has proved its reliability under conditions more trying than could have been produced artificially by man. It means infinitely more than if communication was merely established between two fixed radio stations far apart on the earth's surface, such as New York and London. It may be only a matter of a few months before some means may be found to transmit photographs by radio even from such a frontier post of hazardous exploration as that of the camp at Little America. It most certainly is possible today. A small portable device hooked to the radio transmitter there on the ice-cap could send a daily picture account of the men and their environment intensely interesting to the public. Television even from such a transient outpost will come in time. But television would be of only a limited value to such an expedition, as more detail, at least for printing purposes, can be put into still-picture transmission.

THE ELECTRIC VOICE

PRIOR to 1913, when I developed the audion, or "electrical microscope," the human voice was limited to an audience of a few thousand. Even then a terrific strain was placed on the speaker. Indeed time was when the fellow with the best lungs, rather than the best brains, held sway over his fellowmen. Many of our old-time orators and political figures simply had more steam than the other competitors of their day. In 1912 I succeeded in applying the audion, or three-element vacuum tube, in cascade connexion to the amplification of latent sound values. This was first applied to the long distance telephone lines of this country. Later the same idea was applied to the amplification of the sound of the human voice in the air, so that a speaker, speaking in a normal voice, could be heard by hundreds of thousands of people at one time, and assembled in various cities — in fact the audience was limited only by the equipment available for the purpose.

The electric voice has had and is having an enormous effect on civilization. No longer is brawn the peer of brain. The stentor of ancient Rome, who held the crowds by his bellowing voice, even though his words might be those of his masters, is now a thing of the past. The electrical stentor bellows forth, but with the voice and the personality of the speaker himself. Brain now comes into its own, thanks to the help of the scientist.

BROADCASTING

It is doubtful whether science has contributed in one single instance more to present and future civilization than it has in the gift of broadcasting. Originally the radio telephone was intended as a means of individual or private communication between individuals. In 1907 I began to build radio telephone transmitters for the United States Navy. As a means of testing these devices I placed them in operation on the air and played phonograph records by the hour. The tests attracted wide-spread attention and gave me the idea of mass communication, or "broadcasting." Two years later Caruso's voice was actually broadcast from the stage of the Metropolitan Opera House. Other stars were later broadcast. I continued my broadcasts until 1917, and resumed after the War, first in New York and then in San Francisco.

Following this in 1920 the Westinghouse organization in the East became interested in this idea of broadcasting, and began a regular service from its Station KDKA at Pittsburgh. Broadcasting struck the public fancy. It grew rapidly. First came the programmes placed on the air, followed by the public urgently seeking equipment to listen in. There began the growth of the radio industry as we know it today, with finally more and more broadcasting stations and better programmes to cater to the millions of listeners-in. Business soon saw here a wonderful medium for the commercial so-called "good-will" message (too frequently crass commercial advertising, breeding anything but "good-will"), and so sponsored the programmes, providing thereby an assured means of support for the radio stations.

Radio broadcast now has the power to enfold the entire land in a mantle of music, to breathe into every ear which cares to listen voices of comfort, of nightly companionship with the world's doings, and the world's best minds. "Just a song at twilight," but its lovely echoes may be heard in the miner's cabin, in the rancher's hut, in the living-room of the old farm-house; over the mountain range, beyond the desert, across the silent prairie, over the wastes of sea. Who can say what emotions are not awakened, what souls that were deadened, what hearts long embittered by loneliness, may not be stirred to a new life, a new outlook, by that sound ?

When one seriously considers the human side of this broadcasting idea, and its possibilities, he must admit that it possesses potentialities for universal education, and for all the train of good which results from universal education, which can be compared only to that brought through the past five centuries by the art of printing. Only this new revolution will grow to maturity in another decade instead of 500 years — a graphic commentary on the acceleration of man's present progress.

RADIO SOLVES AN ECONOMIC PROBLEM

BUT THE political and news-spreading applications are by no means the most important uses of radiophone broadcasting. The ability to put daily and nightly a well-chosen variety of entertainment and education into every household throughout our land in city and town and hamlet — into every farm-house, every ranch shack, every mining camp and cross-road store — is one whose far-reaching power for genuine, lasting good, which no one can now fully estimate.

For years the tide, in our own and foreign countries, has been setting in from the rural to the city districts, from the sparsely peopled to the already crowded sections. The producer class is steadily diminishing relatively to the ever-increasing class of consumers. This of course means constantly increasing costs of living — in the cities, with no such corresponding increase in returns to the producer, the farmer, the stock-raiser. Their lives are hard at best, and for the most part lonely, especially during the winter months.

The problem of obtaining and keeping farm labor becomes each year more difficult, as the call of the city and even of the small town becomes more and more attractive. The desire for shorter hours of labor, the craving for excitement or recreation at night, the gregarious instincts of man — are calling the youth, boys and girls, from the farm to the town, from the town to the city. The evil cuts both ways — depopulating country and congesting cities. Nothing can be of greater service to the entire nation than an agency which will supply to the dweller in isolation, the laborer and the youth on the farm, and in the country villages, a genuine and ever-novel means for entertainment, for amusement, and enjoyable education.

It is the almost complete lack of these elements, more than the isolation from the crowd, which has rendered life on the farm and in the smaller towns so dismally monotonous, so dull. There are frequently long intervals in which the work on the farm is itself not hard, or would not be could a little hired help be retained; but ah, the loneliness, the deathly monotony! So few of us are self-resourceful, or good companions to ourselves.

To such as these, to all of these, and therefore to almost half of our population, comes the radiophone as a twentieth-century cure for an ailment centuries old and rapidly growing worse.

Pause a moment to consider what this widecast diffusion of electrical knowledge, this arousing of universal interest in radio and electrical technics will mean to the American nation if long continued. We shall rapidly become an electrical people — the elements at least of electrics and physics, heretofore a closed book of mysticism to all but a comparatively few, will inevitably become the daily thought and talk and custom of our masses. The man or woman who heretofore has complacently admitted that "all this wireless is beyond my grasp or comprehension" will become a curiosity — as much of an ignoramus or mental moss-back as are those who know not what causes the tides, or that the stars are similar to our sun.

A generation of such intimate familiarity with electrical apparatus and such knowledge of the fundamental laws governing radio phenomena must inevitably bring about a rapid development in all electrical lines which, lacking other stimulus, would require perhaps a hundred years to equal.

This, I am convinced, is to be one of the lasting, far-reaching, wealth-producing results of this new American institution. Those who are listening in nightly to radio entertainment and instruction will surely take kindly and understandingly to brief, elucidating lectures on the principles involved in the apparatus they themselves are personally handling — to clear, concise explanation, by masters in the art of electrical instruction, of the physical principles which make possible this modern miracle. And other and more general scientific information will be assimilated by thousands of Americans who otherwise could never be induced to read or attend lectures on science of any description. And this primary scientific education will be made so easy of acquisition in the home, that its seeds of knowledge cannot fail to strike into a myriad of receptive minds which could in no other way receive it, awakening in many of them a hunger for new and deeper knowledge.

Broadcasting has served to weld the people of our nation into a homogeneous, well-informed and somewhat cultured body. A genuine appreciation for good music has at last been cultivated in America. The range of knowledge of the average individual has been increased many fold by broadcasting. The barriers between rural and urban life have been torn down, since rural family and city family listen to the same programmes. A most remarkable aid to extension, or adult, education has been provided by broadcasting. But the manifold possibilities here inherent in this new medium of contact have as yet been scarcely visualized.

Broadcasting must aim to mould future civilization along lines of greater knowledge, finer culture, and a broader understanding. We are tearing down former barriers. For the humble workman's cottage and the millionaire's mansion enjoy alike the benefits of radio. It is the democratization of music, of the histrionic art, of the banquet-hall speeches, of the political rostrum, and of culture at large. We aim to apply radio in our schools, so that our leaders, in every field of achievement, may appear in many schools to thousands of pupils at one time.

International broadcasting is now in the making. Powerful short-wave stations in the United States transmit their far-reaching voices to all parts of the world to be re-broadcast to listeners-in of other lands. Also the short-wave programmes of other countries are being re-broadcast here. In this field technical progress is moving rapidly ahead. Soon international programmes will become commonplace. Strange and far separated peoples will then come much closer to a genuine community of interests. The greatest weapon for peace will be at hand — *Understanding*.

Even while this chapter was in type came the thus far most startling demonstration of the vast potentialities of the International Broadcast. When, to welcome in London the Delegates to the Naval Reduction Conference King George of Great Britain spoke into the radio microphone, an estimated possible audience of one hundred million listeners scattered over the face of the civilized globe harkened to his friendly words.

The powerful short-wave transmitter spanned the seven seas, to remote shores where various national broadcast transmitters picked up its waves, unspoiled by static, and respread the kindly message to their own millions. No one hearing the actual opening of that International Conference for Disarmament could fail to be impressed, first with the miracle of science that at last had made it possible, and secondly involuntarily, perhaps subconsciously, to recognize that the distant day of Peace on Earth was definitely nearer to its dawn.

And in more ways than the strictly technical had Radio brought that first world message into being. No longer must a favored few await a summons into the awed presence of Royalty. Radio has at last brought the King to the Commoner, the Ruler to the very hearth and bedside of his humblest subjects, soon destined by that same token to be themselves the Ruler.

In the United States in 1929 an estimated total of 250,000 to 300,000 employees were engaged in actual manufacture and sale of radio equipment of all types. These sales were handled by approximately thirty thousand dealers. The total volume of radio business during 1929 was about three-quarters of a billion dollars. Contrast this with a two million dollar gross in 1920, and one may form some conception of how this means of communication has grown in less than ten years. And yet these fantastic financial figures do not begin to express the changes which the radio broadcast has wrought in the home life, the world-outlook, the advancement of education and culture among the American people.

Science no longer works for kings and feudal barons. It recognizes only one ruler — the human race at large. It aims to make its fruits available to the greatest number of people. That is the gauge of success. Engineers have labored feverishly, incessantly since 1920 that the benefits of science and the radio might be supplied to mankind in the broadest and most liberal fashion. Today we are seeing this wish fulfilled.

IN CONCLUSION

The whole scheme of communications, by electricity, by news print, by post, is aiding mankind to transact its business, its social affairs, its diplomatic relations. But back of all this, broader and deeper in results and wide-spread benefits, although quite involuntary and unforeseen by most of the agencies now involved, is the quiet, constantly working tendency toward education, culture, broader-mindedness, community of aims, mutual understanding. It is a far-reaching, slowly extending step toward a common, or at least a commonly understood, language. And finally to international friendship, international comity — an End of War.

VII — MODERN INDUSTRY AND MANAGEMENT

By Dexter S. Kimball

I

IGNORANCE is the chief source of fear. Men are always afraid of the things they do not understand be they people, books, machines, or changes in surrounding circumstances. Without doubt much of the criticism now being levelled at modern industry and management emanates from those who are not well informed concerning the nature and growth of science, pure and applied, and who find themselves in new and unfamiliar surroundings to which their old philosophies of life do not apply. It is difficult for many of them to adjust themselves in a world where personal service tends to disappear and as a consequence of which their physical comforts are disturbed. They are terrified at the speed of modern life where men fly like birds and where time and space have been obliterated by the telegraph, the telephone, the radio, and the steam engine. The philosopher is disturbed because many of the ancient theories of life do not apply to modern days. The theologian is worried because modern science has disproved his pet superstition. The artist is in despair because he sees new forms of industrial art appearing that are *different*. The poet, as yet, has found little in modern industry to inspire his song and the economist is perplexed to find his apparently bomb-proof axioms suddenly superseded by new and startling economic theories. Hence comes the flood of criticism, too great to be enumerated here, carrying the general implication that modern applied science, while undoubtedly conferring some higher degree of physical comfort and pleasure upon many, is destructive of much that is good to a degree that makes doubtful the beneficence of the entire development.

Now no well-informed person will deny for a moment that there are many dark spots in the modern industrial picture, much less deny the charge that the transition from handicraft to machine production has been accompanied by much suffering. Nor will he deny the fact that modern industry and management are faced with many difficult problems upon the solution of which depends the happiness of millions of people. The problems of increasing dependence of the worker upon capital, and the danger of unemployment, through increasing improvement in industrial equipment, of themselves, are sufficient to steady the enthusiasm, of over-zealous industrialists and are problems so basic and far-reaching in their importance as to make the complaints of the artist and poet very trivial in comparison, at least to the mass of humanity.

It should be remembered, however, that all advances, whether industrial, political, or religious are, and always have been, accompanied by trouble and suffering. It appears to be inevitable that no great reform or betterment can be accomplished without suffering upon the part of many. I would remind the critics of modern industry that such political and religious freedom as we enjoy were won literally through blood and tears; that these liberties are retained even now only through constant watchfulness and that there is no lack of people who would like to see a return to old political and religious organization just as many critics of modern industry preach a return to mediæval handicraft, or at least a large abatement of modern methods. Make no mistake in this matter. If we shall achieve *economic freedom*, a high standard of life, security and delight in work and leisure, as we have to some degree achieved *political* and *religious* freedom, it will be through much trouble and against no little opposition.

And it is economic freedom that modern scientific and industrial methods promise above all else. Under all preceding forms of industrial organization the many were compelled to exist in comparative poverty in order that the few might enjoy physical and mental comfort. And for the first time in the history of the race there is held out the promise of industrial methods so productive that *all* men may enjoy some of the good things of life, a promise of an approach, at least, to universal well-being where all may have food, clothing, shelter and some degree of mental development. There is held out a hope that disease may to some extent be controlled and that compulsory poverty with its concomitants of vice and misery may be made a distant memory. If in the progress of such a change it be necessary to remodel art, literature, economics, and some of our philosophies of life, I for one am willing to take such a risk in the confident belief that out of a new and better industrial background will spring a new literature, other forms of art better adapted to new conditions, and higher and better philosophies of life. Some of these changes are even now well under way as evidenced by our modern architecture and much of our machine-made product.

II

THE GREATEST and most important problem that has faced man from time immemorial has been the problem of subduing his environment and wringing from an unfriendly world a comfortable existence. And only as he has been able to subdue his surroundings has he progressed in the arts and finer aspects of life. It is an amazing thing that in the long ages of his life upon this planet he had given so little thought to the primary problem of making a decent living. One wonders what the world would be like if the ancient Greeks had turned the searchlight of their keen minds upon the problem of making a living instead of directing it upon speculative philosophy. No doubt they would have done more for posterity than they have done through speculative philosophy, great as that contribution may be. Traditional history, as we know it, deals almost wholly with the deeds and misdeeds of kings and queens and their foolish and wasteful wars. Only recently have historians begun to interest themselves seriously in economic and social affairs. Wherever the veil that hides the life of the common people is lifted, we see countless thousands of men and women working and existing little better than the beasts of the field, struggling to support a civilization with hopelessly inadequate tools of production. This has been true from earliest times down to the Industrial Revolution and it is axiomatic that as the tools of production become more primitive the working classes approach more nearly to slavery. The "good old day," the "golden age" of the critics of modern methods has never existed in any large measure for the working classes.

Consider what the Reverend August Jessup, an English essayist, writes concerning living conditions in England in the thirteenth century and remember that they were little better just prior to the Industrial Revolution. Anyone who makes the assertion sometimes advanced that the modern machine age has increased the misery of the working classes is wholly ignorant of *industrial* history.

> The laborer's dwelling [says Jessup] had no windows; the hole in the roof which let out the smoke rendered windows unnecessary and even in the houses of the well-to-do glass windows were rare. In many cases oiled linen cloth served to admit a feeble semblance of light and to keep out the rain. The laborer's fire was in the middle of his house; he and his wife and children huddled around it sometimes grovelling in the ashes; and going to bed meant flinging themselves down upon the straw which served them as mattress and feather bed exactly as it does the present-day gypsy in our byways. The laborer's only light was the smoldering fire. Why should he burn a rushlight when there was nothing to look at ? And reading was an accomplishment which few laboring men were masters of.
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> As to the food, it was of the coarsest. The absence of vegetable food for the greater part, the personal dirt of the people, the sleeping at night in the clothes worn in the day, and other causes made skin diseases frightfully common. At the outskirts of every town in England of any size there were crawling about emaciated creatures covered with loathsome sores, living heaven knows how. They were called by the common name of lepers and probably the leprosy so called was awfully common. But the children must have swarmed with vermin; and the itch and the scurvy and ringworm with other hideous eruptions must have played fearful havoc with the weak and sickly.
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> As for the dress of the working classes, it was hardly dress at all. I doubt whether the great mass of the laborers in Norfolk had more than a single garment — a kind of tunic leaving the arms and legs bare with a girdle of rope or leather round the waist, in which a man's knife was stuck to use sometimes for hacking his bread, sometimes for stabbing an enemy in a quarrel. As for any cotton goods, such as are familiar to you all, they

had never been dreamt of, and I suspect that no more people in Norfolk wore linen habitually than now wear silk.

Compare this with living conditions in the United States today. Modern industrial methods began to develop in this country about the middle of the last century coincident approximately with the adoption of interchangeable manufacturing or mass production as it is more commonly known. By the end of the century the modern factory had practically superseded handicraft production, the census of 1900 being the first to omit mention of handicraft products. During that half century more progress was made in developing man's productive capacity than in all the long centuries he has been upon this planet. Since that period our industrial system has been expanded and developed to the degree that today we are the most highly productive people that have ever existed. The mathematical measures of this growth are almost startling. The Census of 1850 gives the per capita wealth of the United States as $383. This ratio has risen steadily through good years and poor years until today it is approaching the unprecedented figure of $4000. The national wealth last year was estimated at $400,000,000,000, and the national income at $90,000,000,000. No such sums of money have ever been in the possession of any people, and the speed at which this vast wealth has been created exceeds anything in history. Moreover, both the national wealth and national income continue to grow rapidly and there is every evidence that the per capita wealth will be greatly increased as time goes on.

There are several reasons for this great advance in material wealth. Vast natural resources and an inventive and industrious population have, of course, been great factors. But beyond question the most important influences have been our modern industrial methods and our extended use of power and new methods of communication. It is significant to note that the per capita wealth of the United States bears the same ratio to the per capita wealth of England, France, and Germany, as the developed horsepower of the United States bears to the developed horse-power of these countries, being four times that of England and ten times that of either France or Germany. Nor should the influence of science and engineering upon agriculture be overlooked. The great problems before Congress today are not those of finding enough to go around, but of finding out if possible what to do with the surplus we possess. We grow more food than we can consume and if we should turn all of our productive machinery to the task of producing the necessities of life, alone, we should not know what to do with it, so great would be the volume. For the first time in history we are within striking distance of the abolition of poverty and want if we can but direct these agencies wisely.

Truly, as Bertrand Russell has said, if there have been poverty and want since the Industrial Revolution it has been because of ignorance and selfishness. The problem of production has been solved to an amazing degree. The problem of distributing the fruits of industry equitably still remains, and the solution of this problem involves not so much the scientist and the engineer as the voter, the legislator, and the critics of modern industry themselves. It is not the "machine" that is to blame so much as those who control its product.

III

If, however, we are to build a civilization wherein all men shall enjoy the good things of life, industry, business, and government must have definite objectives. First, industry must produce abundantly. It is axiomatic that we cannot have food, clothes, and shelter unless we can produce them, nor education, art, and literature unless we can produce a surplus over and above our base material wants. It is clear that we cannot have leisure to enjoy the good things of life unless we have an excess capacity in our methods of production, and all will agree that leisure is necessary.

Furthermore, we will all agree, I think, that industry of whatever kind should be honorable and dignified, so far as possible, that it should be conducted in a healthful manner and that it should be made as interesting and attractive as possible. To this end, therefore, management should see to it that all industrial equipment whether buildings, apparatus, or surroundings should be in harmony with these ideals. Much has been done to make factories more habitable, less dirty and less noisy, but much more can be done in this direction. Lastly, management and our government should see to it that the fruits of industry should be equitably distributed. Abundant production is one thing, and equitable distribution is another. The first appears to be fairly well solved even now, but the last is still a difficult problem. To what extent has industry intelligently attacked its share of this programme?

The story of the transformation from the small, old handicraft factory to the present gigantic enterprises is too long to be discussed here, but some of the salient points may be noted. Two influences have been most effective in this growth. The first is the increased size of modern apparatus as illustrated in ships, bridges, locomotives, etc., all requiring larger plant and equipment for their production. Secondly, and most important, is the principle that the unit cost of production in general can be reduced as the quantity to be made increases. Hence comes the growth in size of plants manufacturing clothing, shoes, soap, automobiles, radios, etc. But the lower the unit cost the greater the volume of sales and these effects act and react upon each other until of such products as watches everybody possesses one. An elementary example may make the cycle clearer. Suppose that it costs $9 to make a machine part by hand, but that with a certain power tool costing $400 it can be made for $1 which is not an unusual reduction in cost. Then the unit cost of one part including the cost of the tool will be $\frac{\$400 + 1}{1} = \$401$ and the unit cost of two parts will be $\frac{400 + 2}{2} = \$201$, and the unit cost of fifty parts will be $\frac{400 + 50}{50} = \$9$ or the same as if they had been made by hand and the unit cost of 1000 parts would be $\frac{400 + 1000}{1000} = \$1.40$ and so on, the cost decreasing as the quantity is increased. This principle lies at the bottom of all quantity production and is the most important influence in the growth of modern plants.

Now an increase in the number of men employed naturally results in an extension of division of labor and this in turn to *depart-*

mentization, a department being simply an expanded individual. The work of the several departments again is cheapened and made more efficient by the use of special machinery such as typewriters, special machine tools, etc. Again these departments are *co-ordinated* by means of telephones, messenger services, etc., the entire *system* as it is called enabling the complete and intricate organization to function like a great machine. And, as before, the larger the productive output the more costly may be the system since it is of the same character as any other *time-saving* appliance. Concrete illustrations of such an organization are to be found in the great automobile plants, the factories of the Western Electric Company, the General Electric Company and others where as high as 40,000 men may be found in the confines of a single yard. These basic principles, namely, specialized labor and the extended use of labor-saving and time-saving apparatus applied to large quantity production lie at the root of American industrial methods, and are responsible primarily for the low unit cost and immense volume of such products as automobiles, typewriters, radio, etc., etc. Nor are these methods applicable alone to large quantity production. As can be seen from the foregoing example the gain in unit cost is greatest when the number of parts is comparatively small, the advantage decreasing proportionately as the number increases. And it should be remembered that these methods have spread to all manner of industry including agriculture. It is by the use of these methods largely that the problem of production has been solved to a degree hitherto unknown to humanity.

But even more important has been the influence of scientific and engineering *methods of thought* upon all ideas of management and business. As the background of industry has become increasingly more scientific the technically trained man has assumed a leading part in industrial management. If the present trend continues there will be little place in the field of management for those unacquainted with engineering technology. These technically trained men have naturally brought their accurate methods of thought to bear upon management problems. The old methods of management, which unfortunately still prevail in many places, were almost wholly empirical and based upon personal judgment. The engineering method consists of finding out first what the *facts* of the problem may be as a basis for the use of judgment. The most profound effect of engineering thought upon managerial methods sprang from the ability of the engineer to *predict* with certainty the performance of his product. He quite naturally has tried to apply analytical methods to the prediction of the times and sequence of industrial operations, to predict in advance *how, where,* and *when* the productive operations in which he is interested should be performed. Like all new movements this idea had been gathering for some time, but it remained for the late Fred W. Taylor to consolidate this movement and to make a practical example. Volumes have been written on his work and that of his successors, and even the briefest account of this movement is beyond the limits of this paper. It must suffice to note that while the particular form of organization that he established is no longer followed in its entirety, the ideas and principles of management that he enunciated have found wide application.

The general effect of these more refined methods of management is to analyse industrial processes, break them up into detail operations, and assign fewer functions to the workers. They thus tend to extend division of labor and to break up trades and callings into specialized operations in much the same manner as improved machinery of production. Their general effect is to increase production and to decrease cost by reducing the time required for production and the term *time-saving management* is as truly descriptive of their effort as *time-saving machinery* is of modern tools. Now a good modern factory is a clean, warm, well-lighted, and sanitary place. The influences that have brought this about and which are remodelling the old unsightly plants are several and two should be noted.

The first is *industrial legislation.* From the moment that the evils of unrestricted application of modern methods were evident, efforts were made to regulate legally many of the more evident defects. Today industrial legislation in all progressive states protects the worker in large measure against many of the oppressive effects of modern methods which not a few uninformed persons still connect mentally with factory life. This legal defence, which must be examined with care to be appreciated, has reached its highest point in modern compensation acts which aim to protect the worker and his family against the hazards of his calling. We are likely to witness a considerable extension of socializing influences of this character. And in all progressive states the *minimum* requirements in the way of protecting the health and safety of the worker are quite impressive.

The second influence is economic in character and flows from a growing conviction upon the part of management that good working conditions increase dividends. This idea has been experimented with over a very wide field with varying results. Obviously the effect of sightly buildings, cafeterias, entertainment and education for employees are intangible and difficult to measure. Common experience would indicate, however, that a man will do more and better work when his surroundings are congenial. There are, however, certain developments along this line that rest upon more solid grounds and some of them are the results of investigations and measured results by industrial engineers.

It is now an accepted economic fact that it is costly to "hire and fire" workers and that a steady working force is an economic gain. It is a well-established principle that low production costs do not necessarily accompany low wages, but that the very reverse is true in most cases of modern industry. Furthermore, it appears that in the United States, at least, the working class is the largest purchasing element and, given good wages, these workers will purchase freely of the comforts and luxuries of life, thus making quantity production and low productive costs possible. There are, in fact, a number of new economic principles now in development and on trial which promise much for the workers in industry so far as physical comforts are concerned. Space again does not permit of an enlargement on this topic.

The progress that has been made toward a better and saner form of factory life can be fully realized only by men who like the writer *can remember* handicraft factories and the power-driven factories of fifty years ago. Dark naturally, and lighted artificially in a most primitive manner, usually dirty, with little or no sanitary appliances worth mentioning and inefficient in the extreme, one wonders how any intelligent person can mourn for such departed days. It is true, more the shame to us, that even today some relics of this age are still to be found.

Compare such a place with the new factory of the Western Electric Company at Kearny, New Jersey, with its fire-proof construction of steel and concrete, perfect lighting and sanitation and all the necessities that make it a place *fit to live in* as well as to *work in.* Here also will be found a complete personnel department whose sole function is to recruit and care for the working force of 20,000 men. And there are hundreds of such progressive plants in this country as illustrated by the National Cash Register Company of Dayton, the Natural Food Products Company of Niagara Falls, the Gleason Works and Kodak Park of Rochester, the Naumkeag Mills of Salem, etc, etc.

It must be admitted, however, that the vast majority of industrial plants are far from what they should be and could be. It is true that many industrial operations are naturally dirty and disagreeable. The old handicraft tan-yard was as offensive as it could be and probably there will always be much work that is distasteful to the senses. Yet much can be done to remedy these objections to modern industry. A steel mill, for instance, is usually dirty and noisy yet Mr. Ford's rolling mill at River Rouge is a model of cleanliness. This criticism of modern industry is well taken, and there is still need for preaching the necessity and value of cleanliness, good appearance, reduction of noise, the prevention of accidents and more pleasant surroundings inside and outside of the factory. But the tendency is in the right direction and it is hardly fair or intelligent to condemn industry because of such defects any more than it is fair to condemn all management because of misguided administration such as appears to be troubling the cotton districts of the South.

More important than all is the growing sense of responsibility on the part of ownership and management as concerns human welfare; a growing feeling that industry should serve man rather than man serve industry. In spite of many dark spots in the industrial picture, there is much evidence that ownership and management are developing higher ideals as concerns employment. The writer does not make this assertion as an offhand statement, but bases it upon fifty years of close contact with American industry. Tangible evidence of this change for the better is seen in the improved character of modern industrial plants, in the modern personnel systems that aim to place men where they will be most effective, and to see that they work under comfortable conditions. It is even more evident in a willingness to pay good wages for good output in the many places whereby employees may purchase stock in the enterprise and in such eleemosynary devices as old-age pensions, etc. It should be remembered that competition becomes keener daily and that the manager and owner are beset with many difficult problems that threaten the economic existence of the enterprise. Wages must be paid and debts discharged. Modern management is no sinecure. Yet it is to this group of all others that we must look for any large solution of the major problems of industry such as unemployment, old-age relief, accident and sickness insurance, and wholesome working conditions in general. Legislation may help industrial progress and may in some measure protect the industrial worker, but only through great vision on the part of management, only through a keen realization of its responsibility toward humanity can some of the defects of our industrial system be held in check. The problem of production appears to be solved and what is now needed is the application of logical methods for distributing the fruits of industry. This is primarily a problem for management, and our economic and political leaders. Unfortunately, the latter group is a weak reed to lean upon, and will continue to be so until we can develop a much higher type of statesman than now occupies the seats of honor in our state and national legislatures.

IV

Any extended summary of the benefits and disadvantages of the new productive methods is beyond the limits of this paper, but it is desirable to note a few of the most important. First the increased productiveness mentioned in the foregoing has resulted in a higher standard of living, especially in the United States, than has ever been known by any people. This is universally admitted. The material evidence of this improved standard in the use of the automobile, the telephone, the radio, mechanical refrigeration, etc. etc., is too apparent to admit of controversy. Never before has so great a value per man hour been created as is to be found in some of these products that in former days could have been possessed only by the very rich. What formerly were luxuries are now necessities and there is a constant transfer from the list of the former to the category of the latter.

Coincident with this change, there has been a general shortening of the hours of labor. True, there are shops where long hours still prevail, but the general tendency is to shorten the working day. Moreover, this elevation of living standards has been brought about more through the lowering of costs and the vast volume of product than through improvements in our methods of distribution which are still hopelessly inefficient. With distribution methods as efficient as our productive methods, still greater gains could be made in the standard of living.

The second great result of increased wealth has been the development of an educational system that envisages all children as entitled to a basic education. Never before in the history of man has such a comprehensive educational effort been made as is now in progress in this country. The financial cost of this effort is astounding and is possible only because of our productive efficiency. And this educational programme includes not only basic instruction, but also the fundamentals of music and art appreciation. The educational programmes of some of the great western states that envisage instruction for all *men* and all *women*, in school, in the home, and in industry have no parallel in history and are possible only where there is a large surplus income and utterly impossible in the "good old days" of handicraft with its ignorant working classes.

Closely allied to this educational movement is the increased opportunity for travel now enjoyed by so large a part of our people. The automobile in particular has enabled millions of people to see something more of this great land in a manner undreamed of twenty-five years ago. And a great excess of income over living expenses sends hundreds of thousands of tourists abroad annually. Mr. Julius Barnes of the Chamber of Commerce of the United States estimates that American tourists spent in 1929 $700,000,000 in foreign travel. Now travel of all things is educational and broadening. No one who has seen the American tourist invasion of Europe will deny that these tourists need modification and enlightenment of some sort and this international exchange of ideas (and money) is helpful to all concerned. But the outstanding point is that if this movement continues we shall have many millions of citizens with first-hand information concerning other countries in a measure unequalled by any other people. Modern industry has made the world a small place and its boundaries contract daily. It is essential that we know and understand our neighbors. At any rate, education and travel, once the privilege of the few, are rapidly becoming the commonplace for the many.

The third great benefit that has accrued to us from excess income appears in our greatly increased facilities for combating disease. Vast sums of money are going annually into medical centres, medical foundations, and special gifts to combat specific diseases and to support medical research. Medical science furnishes the knowledge for these most noble of all efforts, but industry supplies the vast sums necessary for their prosecution. History again furnishes no parallel for the intelligent concerted attack that is being made upon disease and the results already obtained is so heartening as to hold out great hope for future generations. The "plagues" of the "good old days" before which men stood helpless and died like flies are already things of the past in modern communities; or if they do break out are looked upon not as visitations of an enraged deity, but as a result of human ignorance and folly and curable therefore not by prayers but by science and sanitation. And it is as an ally to this movement that modern industry has been most helpful. Modern plumbing, humble and unappreciated, perhaps, by the critics of modern methods, is possible for all only because of the mass production methods so greatly decried by them. Modern medical science and preventive medicine with its allies of modern plumbing, sewage disposal, and water filtration promise more for the happiness of our children than all the speculative philosophy and incantations that have been evolved since time began. And again it should be remembered that the wide-spread use of sanitary equipment is possible only through modern methods. Cleanliness is next to godliness, and the bathtub is a more accurate index of civilization than is the automobile or the radio.

Fourth, modern industrial methods are modifying and changing some of our concepts of industrial economics. It has always been held by economists and employers that low wages were essential to low costs and unfortunately not a few employers still hold this view. Under handicraft methods this thesis was undoubtedly true, but it is far from being true where the investment in productive machinery is large. In fact, in many instances, low costs and high wages are synonomous, where high intelligence or skill are necessary to obtain maximum production from the machinery of production. The wages of the American workingman are relatively the highest that has ever yet been known but the costs of production in all products produced in quantity are in most cases lower relatively and in some cases such as automobiles, sewing-machines, etc., the value per man-hour, as has been noted, is the greatest ever known.

Somewhat as a corollary it has been discovered that we are our own best customers and while foreign markets are still of great importance our own people are the largest purchasers of manufactured product as witnessed by the 26,000,000 automobiles owned in this country, a proportion vastly in excess of that of any other country. The old theory which kept costs down through low wages in order that goods might be sold at a profit abroad as illustrated by English practice leaves an impoverished working class at the expense of an enriched employing class. Here is a nice problem for the economist and statesman, namely, to determine how the circulating medium should flow from employer to employee as wages and back again to the employer through purchases.

Consider again the new practice of "deferred payment purchasing" formerly known by the simpler and more plain-spoken title "going in debt" and held to be both economically and ethically unsound practice. Today we as a nation are in debt for automobiles, radio, etc., to the amount of five or six billions of dollars and not only is there no alarm over the situation but economists of repute approve the procedure. It is too early, perhaps, to evaluate fully this new venture in giving credit to the man on the street based largely upon his character and reputation, but so far it has seemingly worked out well. In any case here are new economic theories operating on a vast scale which again have no parallel in history. Possibly only extended experience will demonstrate their soundness or fallibility.

Lastly, our higher standards of living are greatly affecting our ideals of life. All ideals whether personal or national are *ideals of necessity,* so far as their actual fulfilment is concerned. Men in all times have had no difficulty in justifying their acts; the cannibal even can make out a good case in defence of his man-eating propensities. With better living conditions cruelty has diminished and more thought has been given to the unfortunate both at home and abroad. We believe in universal education, partly because we can afford it financially, and for the same reason, organized charity, community chests, and famine-relief drives for the unfortunate of other lands get a hearing where in handicraft times the appeal would be in vain. It is largely for this reason also that so many are interested in the dark spots of our industrial system. They do not "square" with our ideals. American democracy is committed to an endeavor to secure universal well-being where all will have food, clothing, shelter, and some degree of mental and moral development. To this programme we all subscribe and we are critical, and justly so, of the elements in our industrial system that oppose this programme. The evils of handicraft days passed unnoticed, though often worse than anything existing today, either because of the hardness and cruelty of the age, or because people could see no way of ameliorating the wretched conditions. For this reason, also, mediæval philosophy and, for that matter some modern philosophy, is oriented toward the past and teaches that all that was good and all the great leaders of thought belong to bygone days. The modern mind believing in *progress* accepts no such doctrine, but with eyes turned to the future accepts the challenge, even of the impossible, believing that the hope of humanity lies in these modern methods, believing that the good in them outweighs the evil, and that this evil can be greatly ameliorated if not obliterated.

V

THE FOREGOING statements probably will not be seriously controverted. It remains to consider a few of the ill-founded criticisms of modern industry and a few of its real defects. It is reasonable to expect that such great industrial changes as are portrayed in the foregoing could not be inaugurated without considerable uproar, confusion, and change in manners. No doubt modern industry has something to answer for in our noisy cities, our overcrowded highways, our overabundance of cheap and sometimes ill-smelling literature and other elements of the scum that floats on the top of modern life. It is customary to blame *all* the evils of modern life upon the machine, from the late war to the changing sentiment concerning marriage, forgetting that war has been the principal occupation of a large part of the race from time immemorial and that marriage relations had run the entire gamut from polygamy to polyandry with all manner of intermediate relations centuries before the Industrial Revolution was dreamed of. It is not difficult to answer many of these criticisms, but space permits of the consideration only of a few.

Consider first the charge that the machine age is destructive to art, one of the foremost criticisms and not without truth. All great social, industrial, and political changes are likely to be inimical to the art of any group that is superseded by such changes. The barbarians cheerfully destroyed the art of Greece and Rome and Cromwell's soldiers knocked the heads from most of the statues in the English cathedrals and smashed the beautiful stained glass. True art must be an expression of the life of the people that produces it. Modern industrial art finds no place in its field for much of the ancient and mediæval art that is held sacrosanct by so many. The ancient artist, for instance, painted angels with wings sprouting from their shoulders. But almost everybody knows that men, at least, cannot fly with such apparatus, in fact, the mechanism of flight is radically different. A modern city built up of Parthenons would be as incongruous as a skyscraper upon the Acropolis. But if modern industry is displacing old forms of art, it is creating new and beautiful forms in harmony with the new methods of production. The typewriter, the automobile, the great ocean liner, and the locomotive are artistic in a new sense and do not need the ancient carving and what-not to make their appeal. And no handicraftsman ancient or modern could produce a product so artistic and handsome as a high-grade, machine-made woman's shoe. A new industrial art is in the making and who shall say what its form shall be? Surely not those who are wholly uninformed concerning modern production methods. Architecture has already to a large degree freed itself from some of the older inhibitions and some of our large new city buildings, while unlike anything preceding them, have a strong artistic appeal.

Closely akin to the foregoing is the charge that skill of hand is declining. It is true that there is little or no demand for some of the old skilled trades such as cabinet making, smithing, etc., and the old "all around" mechanic has disappeared. But the skill necessary on the part of those who build the primary tools of industry is so far in advance of the old hand worker as to put them in a new class of workers. No handicraftsmen that ever existed could compare in skill with modern "tool makers" so called. Here again is a case where the new supersedes the old, but the new art is not comparable with the old, so different is it in its character.

Another fear commonly expressed is that the engineers and scientists with their terrible weapons will destroy all human life. The next war is to be the last war as all civilization will perish. In all probability that same fear was expressed at sight of the first stone axe and without doubt the discovery of gunpowder raised the same alarm. Yet nothing of the kind has occurred, the race has increased in numbers and defensive methods have always kept pace with offensive methods. There is no warrant in history that the balance will incline markedly to the death-dealing side of war apparatus.

There is an old belief still widely held in some circles that it is dangerous for working people to have much money because in such a case it would be spent foolishly or in a profligate manner. This belief implies that certain people are constitutionally so fitted that they can spend money wisely and that some are not. Now foolish and profligate spendthrifts are not peculiar to any one class, or calling. They are found among lawyers, doctors, professors, students, and I suspect also among the most caustic critics of modern methods. But the general accusation is a libel upon the American workman and his wife and has no foundation either in general observation or in statistics. The latter show rapidly increasing savings accounts and a great increase in the value of stocks and bonds owned by working people. And the average American father and mother will support educational facilities, in order to place their offspring upon a higher economic and social level, to an amazing degree. Our higher level of existence as stated has naturally been accompanied by some noise and confusion, and not a little waste of money upon things that are of no permanent value. But I believe that the rank and file of our workers are sound mentally and emotionally, and as we develop a higher and richer civilization, they can be trusted to spend their earnings as intelligently as those who have greater wealth or who are critical non-producers.

A common criticism of modern methods concerns religious beliefs. The writer has before him a statement by a well-known critic of modern industry to the effect that "The Power Age has broken up religion to a marked degree." Such statements are as difficult to prove as they are to disprove. Undoubtedly science, both pure and applied, is antagonistic to superstition and dogma but it has yet to be proven that they are antagonistic to true religion. It has always seemed to the writer that the burden of proof in this matter is upon the ministry and not upon the engineer. Science, pure and applied, has made it more difficult for thinking people to believe unreasonable things and universal education has vastly increased the number of people who are bold enough to interpret the sacred writings for themselves. The fact that a decreasing number may subscribe to the tenents of some branch of the church is no sign that true religion is declining, but rather that the church is not meeting modern needs. When the many branches of the church bury their wide differences of opinion concerning the Gospel and present a rational interpretation of the Scriptures they will find no lack of support. The age of "child-like faith" upon which they so long depended is rapidly passing away.

The aforesaid critics should remember that wide defections from current forms of religion were constant and common occurrences under all handicraft civilization. And the efforts of those who *believed* to compel those who did *not believe* to conform is the basis of some of the most gruesome chronicles of the race. Modern industrial methods did not introduce the phenomenon of disbelief in current forms of religion, but it has done much through the dissemination of knowledge to protect those who do wish to exercise their own judgment on such matters from undue pressure of any kind. I have no fear for Truth. She is a sturdy person and not easily upset. And if modern thought will give us a clearer view of her gracious attributes the world will be the better for it.

There are many other criticisms that could be answered in a similar manner if space permitted. There are a few criticisms, however, that are of far greater importance than any that have been discussed and which should engage the attention of all statesmen and industrial leaders. The first is the tendency of modern methods to separate the worker farther and farther from the ownership of the actual tools of production and thereby to reduce his economic independence. It is sometimes asserted that under handicraft methods the worker enjoyed full economic independence. Of course, this is a false assumption since there cannot be complete economic independence where there is any division of labor, but it is true that as industrial undertakings become larger and division of labor is extended the worker's economic independence is reduced. A little comfort is advanced by these writers who point out that about 15,000,000 people in this country own stocks and bonds and these writers suggest that through these means the workers may again own the tools of industry; no doubt a vain hope.

Another movement that militates to reduce the worker's economic independence is the tendency of modern methods to destroy or greatly modify some callings while at the same time creating new industries and callings. Because it is not always possible to adapt workers in a disappearing calling to the demands of some new ones, a certain degree of unemployment must accompany any industrial advance that embodies improvements in machinery or processes. This unemployment may be temporary or it may be permanent so far as the worker's original calling is concerned and he may be compelled to accept work at lower pay in order to live. On the other hand, new industries are constantly making new opportunities. The manufacture of sewing-machines, typewriters, automobiles, watches, radio, electrical machinery, etc., etc., have opened up opportunities for employment, and have provided work for millions of people who otherwise could take no part in modern industry and who necessarily would otherwise be compelled to work at more menial occupations. So far it would appear that modern methods have created more occupational opportunities than they have destroyed, and this statement is corroborated by such statistics as are available from the Census Reports. The question is a large one and any adequate discussion is beyond the limits of this paper. The interested reader will find, however, more detailed information in the study "Recent Economic Changes," issued by the National Bureau of Economic Research. (See page 93, Vol. 1.) As time goes on it may be that industry will stabilize somewhat and advance with less rapidity, but at present the problem is a serious one.

These characteristics which tend to reduce the worker's economic independence are inherent in the new industrial methods and will be active so long as progress and change in the industrial structure are operative. They cannot be eliminated by minor changes in the system, but can be ameliorated by skilful and enlightened management upon the part of those who control industry. Partly because of these problems the management of industry has assumed greater importance than ever before. In this country in particular men are no longer free to quit industry and seek independence on the frontier. We all find ourselves bound more or less rigidly to the great industrial machine.

Finally, I would urge as suggested in the foregoing that before any caustic critic of modern industry delivers himself of an opinion he study carefully the condition of the common people under handicraft methods from the time of ancient Egypt down to the Industrial Revolution. He should study also the condition of society in the Orient where handicraft still prevails and make a careful comparison with conditions in this country where he sees, or thinks he sees, so many dreadful things. I would then advise him to make a list of the great inventions that have wrought these changed living conditions and study any one of them, say the scientific canning and preserving of food products, and its effects upon human existence. Then I challenge him to strike from this remarkable list of human accomplishments those that in his opinion have been harmful to the race.

VIII — AGRICULTURE

By THOMAS D. CAMPBELL

WHAT PLACE will agriculture have in the spreading civilization of science and machinery? In the past it has been the very foundation of civilizations. It largely sustained the patricians of ancient Rome, the lords and clergy of the Middle Ages, and the landed aristocracy of England and Prussia. Moreover, no small part of the peculiarities in American cultural development has been due to the abundance of land, the long predominance of agriculture, and the system of freehold tenure. If agriculture has been relegated to the rear in the thinking of urban economists, it cannot disappear in reality without pulling down all the rest of the social structure. In spite of the achievements of synthetic chemistry, all the essential food-stuffs still come from the land. It is, even in the most highly industrialized order, a basic branch of economy; it must continue to be, in the very nature of things; and yet, like the rest of industry, it is in process of revolution under the impact of science and machinery. Upon the fate of agriculture hangs the future of manufacturing and urban civilization, with all that is implied for standards of living and opportunity for culture.

THE BACKGROUND

THERE was a time when agriculture was the most independent and self-sustaining of all industries. With the possible exception of hunting and herding, it was the first business in the world. The early inhabitants of the earth got their entire sustenance from the storehouse of nature. They secured their food from the fields and their clothing from the skins of animals. Later they caught and tamed wild animals, collected them into herds; probably stock-raising, another branch of agriculture, is even older than farming. In the course of social evolution, men and women found it necessary to have more food and better clothing and, as a result, learned to till more soil and developed in the crudest way some system of spinning wool and fibre, which in turn they wove into coarse cloth. In this manner the farmer and his family raised all their own food, provided their own clothing, as well as other necessities, and ordinarily did not produce a surplus in excess of their needs. Even our forefathers did this within the last fifty years and many an old farm-house in New England still has a spinning-wheel and other evidences that the family once provided for its own needs.

In the early period of human history the population of the earth was so small that it would not have benefited the farmer to produce more than he needed, as there was no market and he could not dispose of anything he could not use. Neither was there any market for his labor; in fact, there was a surplus of labor at that time, as the husband did the hunting and fishing and the wife did most of the labor in connexion with all household duties; leaving the other members of the family with little to do. There is no way of knowing how long this condition lasted, but it must have been for centuries.

Increase of population, however, could not be stopped and with it inventive and creative genius grew, giving us, through the great era of invention, an increase in industry, as well as in population. People began to collect in villages; these villages grew to cities and ultimately became centres of industry. People living near cities found other means of occupation besides agriculture and, with this increase of population came the corresponding increased demand for food products. It also gave the men in the cities an opportunity to sell their services. It gave people who formerly lived on farms an opportunity to move into town and receive compensation for their time. Farmer boys left the farm because they could earn more money in town. Improved living conditions developed at the same time and with them corresponding increased living costs.

INDUSTRY CHANGES AGRICULTURE

As THE cities became large centres of population and demanded food, the farmer ceased to be a producer for himself only, until now each American farmer is raising food for nine other people besides himself in this country and one abroad. The cities became a market for any surplus which he had to sell. It was not long until a third of our population was concentrated in towns and soon afterwards half of the people lived in cities and with this movement the farmer became a great seller of food-stuffs; in fact, he became a unit in the largest industry of all times — equal to the combination of practically all others, until today, in the United States, Secretary Hyde estimates that we have $80,000,000,000 invested in farms, with an annual production from all sources valued at approximately $12,000,000,000.

The large industrial centres grew so rapidly that it was impossible to produce enough food in the immediate vicinity and their food requirements had to be shipped long distances. Commission and brokerage houses were established. Sale, distribution, storage, and transportation costs were added to the price. Meanwhile, the farmers' living costs increased. The education of his children became necessary, thereby decreasing his labor supply. Commodities and advantages which were considered luxuries fifty years ago are now necessities and, as a result of it all, the farmer became a great producer and the greatest distributor of commodities without a selling organization of any kind, and the grower of wheat, the greatest commodity of them all, became an inexperienced, single-handed competitor for the world's trade. Meantime, all other forms of manufacturing industry became organized with specialized purchasing and selling departments, which tried in every instance to purchase raw materials at the lowest price. This was only natural, but it brought a great hardship on the farmer, as he, the greatest seller of commodities, was forced to compete in an unorganized manner with highly specialized organizations. Elevators and grain-buying companies were established, which, in turn, were connected with exporting companies, or manufacturers. Most of them did everything possible to reduce grades and prices, increase dockage, give short weights in some cases, and take an unfair spread in the price of grain until the farmer revolted and we had the beginning of farmers' organizations. At that, the buyers were little different from the farmers — each one, in turn, was trying to get the better of the other. As evidence, I will quote a true and amusing story: "An Irish wheat buyer in the town where I was born was one day buying a load of wheat from a Scandinavian farmer and the Scandinavian farmer, weighing about one hundred sixty pounds, in an attempt to get the advantage of the elevator company, stood on the scales while the load was being weighed. Soon after the empty wagon was weighed and the farmer was given his ticket and I, as a boy, waiting to get my load of wheat weighed, said to the elevator man: 'Did you notice that the farmer stood on the scales while you weighed his grain?' 'Yes,' said the elevator man, 'and I docked him two hundred pounds for it.'"

TODAY

THE CONDITION of agriculture is the greatest economic problem before our country today — indeed before the world. Nearly all other American industries have had unprecedented prosperity and employees have had unparallelled pay checks. Industry has been buying from itself for the past five years. Its workers have hypothecated their salaries and pay checks for fifteen to thirty months, chiefly by instalment buying, to the extent of five to six billion dollars per year. Meanwhile, the purchasing power of the farmer has diminished nine billion dollars in eight years. Business men, manufacturers, and other thinkers realize this condition and know that it is very necessary for the farmer to become a purchaser again if we are going to maintain our national prosperity. It is a recognized fact that we cannot have continuous prosperity without agricultural success.

There has always been a farm problem. The Pharaohs had it when they were building their pyramids in the valley of the Nile. The Greeks had it, the Carthaginians had it and there is no more serious time in all of Roman history than the revolt of the farmers after the second Macedonian war. The land question then was what the wage question is now to our more complex industrial society. The rift between the rich and the poor went on widening. Cheap grain was shipped in from other provinces and under-sold the Italian farmer. The small farmer had no escape; formerly the mainstay of Italian society in peace and war alike, he drifted from the soil to form a degenerate town rabble, which listened to agitators and unscrupulous politicians who told him that the Government owed him a living. Conditions became so serious that finally the Roman Government, seeking to appease the people, put an established price on grain, but history tells us that it did not solve the problem.

The Russian Revolution was made possible because of the desire of the Russian peasants to own their land. England has always had her agrarian discontent, and now we have it as the biggest and most important economic problem in our country today.

There were many good and sufficient causes for the Non-Partisan League in North Dakota. It is impossible to stampede 600,000 people into a revolt against conditions in three months, as the election of 1917 in North Dakota showed, without some injustice back of it all. It takes years of wrong or unfair practices, either fancied or otherwise, to move people into such a political revolt, and the fear now is that we may have a national Non-Partisan League if our businessmen and our statesmen do not give their time and attention to our own agricultural problem, for no one will deny that we have such a problem.

It is not an easy problem to solve, for it involves our entire national life, economic and social. It has many aspects, and no one suggestion will cure. The average tenant or farmer has little hope or enthusiasm. Their children leave the farm as soon as they are educated or feel their obligations to their parents have been fulfilled. No woman in any other industry puts in as many hours of toil as the farmer's wife.

Few people realize the magnitude of the agricultural industry and its relationship to all business. Farming, as an industry, is greater than all our other industries combined and the manufactured products made from raw farm products and raw farm products themselves equal over fifty per cent of our export business. You can easily realize how important a factor this is when you know our export business averages about $480,000,000 per month. Agriculture in the United States represents an investment of approximately $80,000,000,000. There have been years when the products of our farms sold for $20,000,000,000. This is two-thirds of our total war expense and almost equal to the 1922 appraisal of all the railways, including terminals, in the United States. It requires more power to plow the farm lands in the United States within proper season than it does to operate all of our other industries combined, including transportation. It is not strange that everyone in the United States is more or less interested in the success of agriculture.

Many bills and suggestions have been offered, many ideas proposed, nearly all of which have been rejected without counter-proposals — much to the discouragement of the farmer. He feels that other industries, including labor, have been rather well provided for by our tariff and restricted immigration. Banking and financial interests have been well established through our Federal Reserve and the McFadden Banking Bill. The necessity of a fair return for transportation has been recognized by our Transportation Act and Interstate Commerce Commission. Public utility corporations are allowed a fair return on their investment.

Two million farmers have abandoned their homes since 1920, and the condition of the small farmer is worse than it has ever been. He receives about a dollar for sixty pounds of wheat and the city man pays ten cents a pound for bread. He receives ten cents a pound for pork and seventy cents for corn, while the consumer pays fifty cents for bacon. He receives two to three dollars a barrel for apples which sell for ten to fifteen dollars per barrel, and so with all other commodities except citrus fruits and wool. The margin is too great; something is decidedly wrong.

If the tariff is lowered, the manufacturer and the laborer will suffer. If railway rates be lowered, wages will be reduced and service impaired. If the Federal Reserve system and the McFadden Banking Act be repealed, credit will suffer and panic will stare us in the face. Business confidence will disappear and industrial depression will follow. If co-operative marketing is advocated or government control and price fixing suggested, all commission merchants and city organizations will loudly protest and the cry of special privilege is raised. If the farmers endeavor to help themselves or demand the same advantages as other industries enjoy, it is socialism, unsound paternalism, or radicalism. All of these questions are debatable and I am not advocating or denying them, but the fact does remain that the greatest opportunity today for the industrial chemist and the engineer is in agriculture.

THE FARM AS AN INDUSTRY

Coming back to actual operating conditions on the farm today we find that the engineer and scientist have already contributed their share of improvements and that the resources now available are far in excess of the general belief. The thoroughly modernized farm closely approaches the factory. Organization is complete in every detail. Each department manager has his responsibility, which, in turn, is passed along to the "straw boss" in the field. Machinery is purchased with full consideration of maintenance as well as first cost. Operation costs are as closely watched as production costs in a factory.

The farm is located with as full a consideration of the factors as establish the location of any other industrial development, namely, raw product, labor, and distribution costs. The soil or raw product is chosen by an expert agronomist, who uses the full chemical knowledge of the soils and soil survey maps now available through our Department of Agriculture and other sources. There is no guess work about the soil. Rainfall conditions and temperature charts are available from our Department of Agriculture giving averages over a period of many years.

The labor problem is being solved by the use of machinery and a proper working schedule. There is no difficulty in getting farm labor if you design your equipment so that you can pay the same wage to skilled workmen that they can earn in the city.

Transportation is no longer a problem of the farmer. Our great transcontinental lines, with their branches, already serve all parts of the United States. The universal construction of good roads has completed the network, as the modern truck or tractor can haul farm products over a good road at less cost than is possible over any short-line branch railroad. All of these are products of the minds of the engineer and scientist.

We [The Campbell Farming Corporation] operate 50,000 acres in Montana with never more than 125 men. Our grain is not touched by hand and we have, through engineering and science, solved practically all of the so-called many farming hazards. Two skilled men with a tractor and five drills on our job can seed one acre, 208 feet square, or 43,560 square feet, in three minutes at a total labor cost of five cents per acre. Two men with a 75-h.p. tractor and ten fourteen-inch plows can plow an acre, six inches deep, in sixteen minutes at a total labor cost of twenty cents per acre. This represents a total volume in dirt moved of over 800 cubic yards, or a labor cost of one-eighth of one cent per cubic yard. Two men with an 80-h.p. Diesel engine can plow the same acre of ground at a fuel cost of twelve cents per acre, or one-sixth of one cent per cubic yard. Two men with a twenty-foot combine can harvest an acre of average grain in less than ten minutes at a total labor cost of less than ten cents per acre. The above, of course, are labor and fuel costs only, but they demonstrate how easy it is to apply industrial and contracting methods to agriculture if you use the engineer and skilled workman.

Our camps are all standardized. Bunks are not over-crowded. Each man is provided with a separate bed. Shower baths with hot and cold water are provided at our permanent camps. Mess halls are particularly clean, and good balanced meals are provided. Medical assistance, at the Company's expense, is also provided when needed.

The great obstacle now to the complete functioning of the farm as an engineering unit, is the general belief that farming cannot succeed and the reluctance of capital to finance farming projects. This has caused the smart farm boy to leave the country and he is now directing a great portion of our great industrial enterprises.

It is, however, a matter of fact that we have too many people on the farms now. Ultimately twenty per cent, maybe less, of our population, with the use of modern machinery and industrial methods, will produce all of our food requirements at a profit, and the surplus farm population will be needed to provide for our increasing industrial demands under restricted immigration.

The ideal condition will come when factories will locate in smaller cities, will govern and time their production to co-ordinate with the farming seasons, thereby giving permanent employment to all throughout the year. This, in time, will be accomplished by the big farm itself through the use of its by-products — manufacturing during the seasons when field work cannot be done. Ultimately the by-products of the farm will bring the industrial farmer more net income than his crop. We expect to do this with our flax straw within the next two years, and, later, with our wheat straw. It will not be long until the industrialized farm will make its own paper to cover the land between the crop rows, as is now done in Hawaii, from its own cellulose products. This will conserve moisture and destroy weed growth. Execellent material is now made in Germany, using half hemp and half low-grade, cheap cotton, or half flax straw and half cotton, at a cost much below the cost of all cotton. They are now making paper from corn stalks in Iowa and it will not be long until the finest paper will be made from wheat straw. A recent writer, according to the twelfth United States census, said: "Cottonseed was a garbage in 1860, a fertilizer in 1870, a cattle feed in 1880, and a table food in 1890. But since that time the industrial use of cottonseed has increased to a marvellous degree. This waste product of the farm, which often occasioned restrictive legislation regarding its disposal, is now the raw material from which over $500,000,000 worth of useful products is made, two-fifths of which is returned to the cotton producer to help increase his profits. Cottonseed is used for the production of oil and cottonseed cake. The oil is used for miner's lamp oil, in the production of soap and soap powders, glycerin, nitroglycerin, and pitch, which is employed, in turn, in the manufacture of roofing paint and composition roofing.

"The four-year average production of corn in the United States is 2,676,220,000 bushels. For each bushel of shelled corn there are fourteen pounds of corn cobs produced. The annual production of corn cobs is therefore 19,000,000 tons, which now largely goes to waste. The Bureau of Chemistry of the Department of Agriculture has studied the possibilities of the use of this waste in industry quite thoroughly. When corn cobs are submitted to distillation, various important chemical products are obtained. One hundred tons of corn cobs produce, on distillation, seventy-five tons of adhesive, thirty-five tons of cellulose, three tons of acetate of lime, and one and one-half tons of furfural. Furfural has many uses in industry. It is valuable as a paint and varnish remover, it is used in the manufacture of bakelite and to make synthetic resins, and as an anti-knock substance in gasoline, and it may some day really supplant gasoline as a fuel for motor cars and other combustion engines. About ten per cent of corn cobs by weight is furfural.

"For every bushel of wheat produced on the farm there are also produced eighty pounds of straw: the wheat has a market value while the straw is a waste product. Yet a ton of dried wheat straw on being distilled in the absence of air gives from 10,000 to 12,500 cubic feet of purified combustible gas; 625 to 640 pounds of carbon residue; ten to twenty gallons of valuable straw oil and 400 pounds of pitch. The straw oil is very similar to coal tar and may serve as a valuable source of many new chemical products. From these straw products roofing cement, auto enamel, metal paint, carbon valuable for various industrial uses such as in the manufacture of rubber tires, auto top dressing, barn paint, fly spray, stock dips, germicides, boiler scale remover, rust eliminator, etc., have been produced and are now offered for sale on the market.

"Cork was formerly the most desirable form of insulating material, but the world's supply of cork is not keeping pace with the world's demand. The methods by which cork is produced are also primitive and uneconomical. The United States Forest Products Laboratory at Madison, Wisconsin, has developed a process for producing a new type of insulating material from wheat straw. A manufacturing concern in St. Joseph, Missouri, is producing this board on a twenty-four-hour production basis and is turning out 125,000 square feet of board every working day. The straw board has structural strength as well as insulating value and is meeting with a ready market in the industrial world.

"Sugar cane bagasse, the waste product left after the sugar has been extracted, was formerly used only as a fuel. It is now manufactured into insulating board, and a new market is thus created for a by-product of the farm. The yield of sugar cane varies from twenty-five to forty-three tons per acre. A ton of sugar cane will produce five hundred pounds of wet bagasse, and the price paid by the insulating board manufacturing company is $.25 per ton. A low yield of ten tons of sugar can thus bring to the farm an additional $2.50 per acre to help reduce the cost of producing sugar cane, while a high yield of forty tons of cane per acre would mean $10 additional for what was formerly waste material.

"Insulating board is also manufactured from other farm waste products. A company in Dubuque, Iowa, is producing such board from cornstalks. It is claimed that 2000 square feet of wall board of high quality are produced from a ton of cornstalks. Iowa alone produces 10,000,000 tons of cornstalks, sufficient to produce 20,000,000,000 square feet of wall board per year.

"Most of our paper now in use is made from wood pulp but paper has been made from many farm wastes. Straw was at one time used as raw material. Any plant with a heavy growth of fibrous material is a potential source of paper manufacture. Sugar cane begasse and cornstalks are interesting possibilities for such use. In fact a paper factory is already in operation for the production of paper from sugar cane bagasse in Cuba.

"A good quality of paper is now being made from cornstalks. A factory has been established at Tilton, Illinois, by the Cornstalks Products Company. During 1927, 10,000 tons of baled cornstalks were collected by this company for the production of paper at an average cost of $8 per ton. The farmer received $1.50 per ton as his share of the compensation, the company assuming all cost of collecting, baling, and hauling the cornstalks. The yield of cornstalks per acre would be about two tons, so the amount received by the farmers for this waste product is an important item in reducing the cost of producing corn. The proposal to use cornstalks for the manufacture of paper opens up all kinds of possibilities regarding this most important crop. It furnishes the farmer with a new source of revenue, and may also completely revolutionize the methods of producing, harvesting, and utilizing corn.

"In the manufacture of paper from cornstalks a certain amount of valuable by-products are obtained. The pulp from the stalks is treated with water which is used over and over again. The resultant solution is very rich in pentosans which have value as adhesives and as stock feed, particularly when mixed with alfalfa meal. Wood sugar or xylose is another by-product which has value as a substitute for ordinary cane sugar in certain functional diseases. It also is used in the manufacture of artificial silk."

Farming offers the greatest field for the application of industrial methods before the engineer today.

Modern farming correctly carried on is ninety per cent engineering and ten per cent agriculture. The Department of Agriculture publishes pamphlets referring to agronomy, soil culture, time of planting, amount of seed, and every other detail, which can be read for each crop, in many instances in an hour's time. This information is so much better prepared by the Government that it can be done by the individual farmer that it is useless for the farmer to spend his time experimenting.

Farming is a manufacturing business, as well as a type of agriculture. It involves all the requirements of manufacturing and it is at the same time the most interesting type of contracting: A contract with a bonus and penalty clause — a liberal bonus if the work is done within season and in proper time and an almost fatal penalty if the work exceeds the time limit.

There are but two types of farming under present industrial and economic conditions in the United States; the small farm operated by the farmer and his family without any payroll at all and the large farm operated as a factory with high priced, skilled men, factory production methods, technical men, and industrial management. We shall always have the small farm with us; in fact, it is most essential that we do. The small farmer will operate truck gardens and intensified units near our industrial centres where the transportation costs will to some extent offset labor costs. Such a type of farm will be a home as well as a business and will always include a great portion of our rural population. The large farm will operate on less productive land with greater transportation costs and less investment per acre. Practically all the work will be done by machinery with a larger output per man and a resultant higher pay. Lands which are now marginal and unproductive will be profitably farmed through industrialization, as the growth in population demands it. We have literally millions of acres of land in the United States now unused which can be profitably farmed on the factory production basis.

We realize from the growth and size of the agricultural industry that it has now reached a stage in which it must be given the same thought and attention as is given to other manufacturing and contracting businesses. Assuming that the farmer has the same advantages of tariff which other industries enjoy, we still must follow the example set by the manufacturer. The location of the farm for the production of a certain crop is just as essential as the proper location of a factory; rainfall, transportation, market, and labor supply are all factors in its success. The determination of rainfall is just as easily acquired from Government records as the knowledge of precipitation is learned by engineers when locating a hydro-electric plant. Crops of all kinds produce in almost direct proportion to the precipitation. Government records can be obtained for fifty to one hundred years. The transportation is a most important factor in the marketing of crops. Manufacturers always consider freight rates and distribution when locating a factory.

Farm labor is just as essential as factory employees although it is harder for the farmer to locate near centres of population than the manufacturer. The manufacturer can easily get his labor requirements by locating near these centres. The farmer can, nevertheless, solve this to a great extent by the use of improved machinery. A manufacturer always looks into the marketing of his commodity; the same identical facts apply to the manufacturer of crops.

Industrialization of farming requires capital the same as in any other business. Few people realize that it requires approximately $7.00 per acre to cover the cost of machinery on an economical unit. It is necessary for our financial men to have a better understanding of agriculture and more confidence in its success. I feel that this will come when the engineer and the businessmen submit farming projects to capital with the same degree of accuracy and prepared reports as has been done in other lines. Capital can always be attracted if ordinary return of interest can be assured with a reasonable degree of safety. If we can convince capital that farming can be a success, we will have overcome the greatest obstacle.

Farming, to be a success in the United States, must, along with tariff protection, have a system of accounting and a record of costs. It will require the services of technical men in order to reduce these costs and establish economical units. It is positively absurd to think that the same size farm is applicable to all parts of the country or that the old homestead entry of 160 acres of land is applicable to modern times. All other industries have established economical units, such as 2000-barrel flour mills, 1000-barrel cement plants, 50-ton blast furnaces, etc., but the farmer in most instances is still farming the same acreage which belonged to his forefathers.

Had any of the Egyptian kings visited the United States one hundred years ago, they would have found practically the same instruments of agriculture as were used several thousand years ago. It is only within the last fifty years that any great improvements have been made in our farm machinery, and this has been done by the manufacturers of agricultural machinery and their engineers.

The first great steps in this reduced cost of production were the invention of the binder and the cotton gin. Later came the improved types of threshing machines operated by horse-power, then by steam, and later by the internal combustion engine, until machines were produced which can thresh over four thousand bushels of wheat in fourteen hours. But real economy in harvesting and threshing was not attained until the invention of the combine. The combine has had to go through the universal opposition that every new machine encounters, but has finally proved its merit, and it is my belief now that no farmer in the United States with one hundred sixty acres of land, or more, can afford to be without a combined harvester and thresher. The present combine at a reasonable cost is the most outstanding development in agricultural machinery that has ever been accomplished. It has done more to eliminate care and anxiety from the farmer's wife and to reduce the cost of harvesting and threshing than any other method which has been developed. A product of the engineer, and only one of many.

It is only a question of time until most of the work on all farms will be done by electricity. Power companies will give attractive rates and plowing will be done at night. Ultimately power will be broadcast for farm purposes to all parts of the United States without the use of transmission lines of any kind.

ENTER THE ENGINEER

WHY SHOULD some of our best economists oppose the application of engineering principles for the elimination of hard labor on the farm? What type of reasoning would demand that the women and children on the farms continue to give hours and hours of weary labor most of their lives, without compensation, just because some academic author insists that labor-saving devices will break down the great social and home structure on our farms? From the beginning of time women have carried the burden of successful farming. Something is decidedly wrong in this great prosperous country of ours when it is necessary for the mothers and children on the farms to work eight hours twice a day nearly all of their lives for practically nothing. Ask any pioneering woman who has spent the best years of her life on the prairies and you will soon learn that the engineer has done and will do more to make life easier than all the theories advanced by our cynical critics.

Why should work be done by hard labor on the farm and not in the factory? Why should the farmer's wife carry tons of water during her lifetime when a small gas engine or electric motor will eliminate the drudgery? Why should the farmer's wife suffer the care and anxiety of the large threshing crews when two men can operate a combine? Why should the farmer's family be deprived of the advantages, comforts, and conveniences which those who live in town constantly enjoy? Read "Wild Geese," "Peder Victorious," or "A Lantern in Her Hand" and you will better understand.

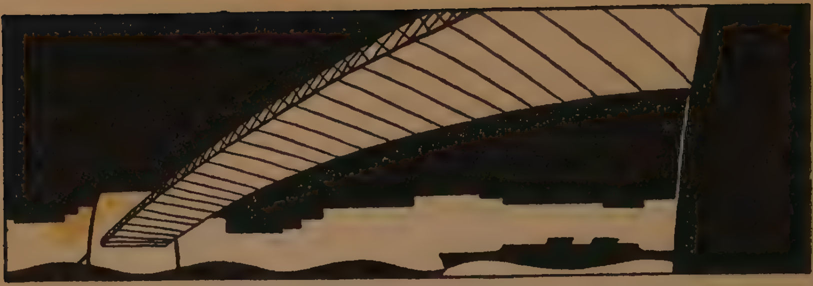
The engineer is going to do for agriculture what he has done for all other industries. He has given many comforts, advantages, and pleasures already to the farmer's family and will continue to provide more. All other industry has increased its output per man many times. The economical unit is well established. What chance has the farmer to engage skilled men when they can earn several times as much in the city? What inducement is there for the farmer boy with brains to remain on the land when he can be more prosperous in the city where capital will finance his ideas? We have too many people on the land now. Less than twenty per cent of our population will be on the farms in another twenty years. This farm population will drift to the city to fill the requirements of our ever-increasing industrial demands.

The farmer of the future is going to be a well-trained, well-educated business or technical man, with just as much interest in art, culture, and the better things of life as men in any other industry. The farmer's wife, as a great number now are, is going to be a cultured, well-educated woman and in many instances a college girl. Seventy-eight per cent of all farmers' sons now go to college and seventy-three per cent of all farmers' daughters attend some college institution. The home on the farm will have all modern comforts and conveniences. It will have a well-selected library — good pictures will adorn the walls and the furniture will give evidence of good taste and judgment. The radio will continue to furnish news and entertainment. Television will soon project Grand Opera and other forms of entertainment on a screen in the farmer's living-room. The automobile has already eliminated distances and added much to the social and community life. All of these are products of the engineer's mind and the next few years will see even greater wonders. Hard labor and drudgery will be entirely eliminated.

The engineer, particularly the mechanical and construction type of engineer, and the industrial chemist are going to be the most important factors in the solution of the agricultural problem. They are going to do for agriculture what they have done for industry.

By-products alone will bring values several times in excess of the crop. Industry long ago accepted the advice and reports of the engineer, and recently has not only accepted his advice, but has adopted him. Twenty-five years ago, when many of us were being graduated from college the engineer was consulted and sometimes called in at directors' meetings — to be dismissed immediately afterward. Now he is invariably a member of the Board — very often the vice-president, as well as chief engineer, and there are many instances in which the chief engineer has become the president or general manager. Businessmen and the owners of capital are beginning to realize that the modern engineer is a good executive as well as a technically trained man.

Farming will soon be recognized as a dignified business. People will give it the classification to which it belongs, and it will then attract the smart, ambitious young man. The biggest industrial opportunity in the United States today is in agriculture, and the broadest field for the technical man is in agricultural engineering. His genius with the aid of the business man will ultimately solve our farm problem. When this is accomplished, a great portion of our people, representing almost one-third of our total population, will be free of the dread of long hours of labor and poverty and the engineer will be given a reward far more satisfying and abiding than wealth, power and position.



IX—ENGINEERING IN GOVERNMENT

By L. W. WALLACE

ENGINEERING, as defined by the American Engineering Council, is "the science of controlling the forces and utilizing the materials of nature for the benefit of man, and the art of organizing and directing human activities in connection therewith." This definition clearly indicates that, correctly understood, engineering extends from the centre to the circumference of modern civilization and is viewed by the profession as a dynamic force, not a determinate set of machines and practices limited by the laws of mathematics and physics. As such, engineering obviously offers instrumentalities and methods to government in all of its operation in which the forces and materials of nature are used for the public benefit.

Although engineering enters into the work of government in ways innumerable, the ground has not yet been prepared by research for philosophic treatment. Moreover the thesis set forth above can best be supported by concrete statements of fact. Besides this, the space limits of this chapter suggest that it would be best to confine our field of observation to the Federal Government of the United States. Thus the larger problem can be illustrated without incurring the risk of losing ourselves in a fog of generality.

Notwithstanding the fact that the first president of the United States was an engineer, in the beginning the Government undertook no extensive engineering works. It was not financially able to do so. Even the construction of the capitol had to be partially financed by personal credit and by state loans. This impoverished Government with 4,000,000 adherents has developed into one with 120,000,000 constituents, and spends annually some $4,000,000,000. From the building of the Wilderness Road it has progressed to the building of the Panama Canal. From no organized engineering services it has advanced to where it has organized engineering services in the Executive Departments of State, Treasury, War, Post-Office, Navy, Interior, Agriculture, Commerce, and Labor. The Department of Justice is the only Executive Department which does not have such a service. To what degree and in what directions engineering and machinery have been influential in this remarkable development is the theme of this chapter.

STATE DEPARTMENT

The Department of State, in addition to its chief function of conducting the relations of the United States with foreign nations, has the responsibility of promoting American commerce abroad. Engineering and scientific developments have reached such proportions that the State Department maintains more than four hundred consular offices abroad, largely for the purpose of developing foreign markets for American manufactured products. The consular reports on foreign trade number about two thousand per month and inquiries from business men average about five thousand per month.

The Department has the responsibility of housing the government's foreign representatives. It is now engaged in providing buildings in many parts of the world for this purpose, which programme requires the services of engineers and architects and the purchase of varied assortment of manufactured products.

TREASURY DEPARTMENT

The Treasury Department is largely occupied with engineering questions. This is clearly shown by the activities of a number of its sub-divisions.

For instance, the Bureau of Internal Revenue determines upon the amount of income tax that should be paid by industrial, mining, transportation, and construction companies. This determination demands a thorough knowledge of technical and mechanical principles and practices as well as of values of production equipment. To meet this need the Bureau employs one hundred valuation engineers.

The Mint is a metallurgical production unit. Its director is a thoroughly experienced mining engineer familiar with the properties and working of metals.

The Bureau of Engraving and Printing is also a production unit dependent upon an engineering knowledge of equipment, materials, and processes.

The Coast Guard, Bureau of Prohibition, and the Narcotics Section each employs qualified engineers and chemists. These services by the very nature of their duties must be thoroughly conversant with engineering and scientific principles and practices.

The Supervising Architect's Office develops the designs and supervises the erection of all government buildings. Under the direction of its corps of 274 engineers there will be expended in 1930 $45,738,370. This amount of money was undreamed of when the founders of this nation had to borrow money to pay the laborers constructing the capitol.

Two hundred years ago the average life-span was twenty years; today it is fifty-six years; in twenty-five years it will be a seventy-year life-span. The U. S. Public Health Service has been one of the prominent factors in this achievement. Sanitary engineering has purified the water supply, combated disease-carrying insects, and reduced industrial health hazards. The Public Health Service Corps of Sanitary Engineers is constantly in the front trenches with the physician, the bacteriologist, and the hygienist, fighting the oncoming devastators of life and health.

WAR AND NAVY DEPARTMENTS

THE very roots of national defence are engineering and scientific developments. Without these any nation would be impotent.

The degree to which these play a part in the fifteen major subdivisions of the Navy Department is indicated by the fact that nine of these are engineering agencies. They are: Yards and Docks, Ordnance, Aëronautics, Construction and Repair, Engineering, Navigation, Hydrographic, Naval Observatory, and the Naval Academy. They will spend in 1930 $105,637,330, which is nearly a third of the total expenditure of the Department.

The modern army requires more than 700,000 different kinds of articles. They range all the way from carpet-tacks and pins to locomotives and 16-inch guns. It has to procure more than 33,000 separate finished manufactured articles. To secure such a variety of manufactured products in the quantities and time required during the World War absorbed practically all the engineering and productive energy of the nation. But back of the war-production crisis were years of painstaking research, design, organization, and production effort. Such activity is pursued regularly and continuously by the War Department and by many in civilian life.

However, the activities of the War Department are not limited to military affairs. Through the Corps of Engineers it discharges important civic functions. The Federal Government since 1824 has followed the policy of improving the rivers and harbors of the United States at federal expense and principally under the direction of the Corps of Engineers. The Report of the Chief of Engineers for June 30, 1928, showed that the number of harbors under improvement was 200, rivers 292, and canals and other waterways 49. The total amount expended on the work for the year was $70,200,000. The Corps will spend in 1930 for river and harbor improvement, including Mississippi flood control, $93,647,600.

It is obvious that in a large measure the War and Navy Departments are engineering agencies, devoting their efforts to controlling the forces and utilizing the materials of nature and organizing and directing human activities in connexion therewith.

DEPARTMENT OF JUSTICE

As a result of the growth of American industry, due primarily to scientific research, invention, and engineering, many trade practices have developed which might without design conflict with existing law concerning unfair competition and the restraint of trade. In fact, a new feature in American jurisprudence is evolving.

DEPARTMENT OF INTERIOR

The Department of Interior among other matters has under its control reclamation, public lands, national parks, education, the Alaskan railway, and the Geological Survey, the problems associated with which are largely engineering in character. In 1930 the Department will spend $24,400,000 on public engineering works alone.

As the late Secretary Lane once said, "The Secretary of the Interior has under his direction more scientifically trained and experienced men than any other man in the world." In the Geological Survey alone there are employed more than three hundred engineers.

POST-OFFICE DEPARTMENT

The Post-Office Department is essentially a material handling and transportation agency. It purchases or leases, through the agency of a contract, every means of transportation and other physical equipment and materials, and recruits, trains, organizes, and directs a large staff of people. There is nothing involved in any of these processes foreign to the daily experience of the engineeer-executive. The orderliness and dispatch with which the mails are handled today are due to engineering and mechanical progress. A measure of the accomplishment in such matters is the reduction of time to dispatch a letter from New York to San Francisco.

In 1860 when the first transcontinental mail service was started, the weekly Pony Express, carrying only fifteen pounds of letter mail, took ten days from the Missouri River to San Francisco. Train connections with New York assured a cross-continental running time of fourteen days (336 hours) with actual delivery time several days more. Then railway development shortened the time gradually to the present six days. Now the fast mail planes fly from New York to San Francisco in thirty-six hours — three hundred hours less than the Pony Express time. The reduction in time is accompanied by an enormous reduction in rate, the air mail costing five cents per letter while the Pony Express charge was five dollars per letter. This remarkable accomplishment of the mail service is a triumph of modern engineering.

DEPARTMENT OF AGRICULTURE

THE casual minded may think there is a wide gap between engineering and agriculture. This is not true because some of the most forward steps made in agriculture in the last fifteen years have been directly due to the application of engineering methods.

In 1927 in eastern Nebraska, following old methods, it cost eight-six cents to produce a bushel of wheat, whereas in western Nebraska where the efficient combine-harvester was used, it cost only thirty-two cents.

In some states the old method of producing corn required sixty man-hours per year per acre. With modern mechanical methods it requires only five man-hours per year per acre.

In the listed wheat area, with improved farm machinery, tractor drawn, one man cultivates three hundred and twenty acres of wheat and works only from 100 to 152 days per year.

These and corresponding results in other phases of agriculture are being realized in a large degree through the efforts of the Department of Agriculture, working through its Director of Scientific Work, the Agricultural and Mechanical Colleges, the Division of Agricultural Engineering, the Bureaus of Chemistry and Soils, Dairying, Forestry, Public Roads, and other sub-divisions. These agencies employing almost five hundred engineers are dealing with soils, soil erosion, drainage and irrigation, farm equipment and buildings, roads, forestry, and many related subjects.

The Bureau of Public Roads has general charge of the national highway programme. The specifications, locations, and construction of all federal aid roads must comply with the mandates of this Bureau. This Bureau annually directs the expenditure of some $80,000,000 of federal money for road construction.

DEPARTMENT OF COMMERCE

THE Secretary of Commerce has the responsibility of promoting the commerce of the United States and aiding in the development of the mining, manufacturing, shipping, fishing, and transportation industries. A brief statement of the functions of some of the divisions shows the influence of engineering on the operation of his department.

Bureau of the Census — statistical information, timely and accurate — is one of the prime safeguards of modern industry. The Bureau has grown to large proportions because of the increasing requirements of industry. Its rapid collection, codification and dissemination of information have been made possible by mechanical developments.

Bureau of Standards — the largest and most important research laboratory in the world — includes aëronautical, automotive, ceramic, concrete, electrical, metallurgical, radio, structural, telephone, and general engineering.

Bureau of Lighthouses — lights the waterways and airways of commerce and trade. It safeguards the navigation of the coasts and navigable waters of the United States, Alaska, Hawaii, and Porto Rico.

Patent Office, employing 650 scientific men and handling over one hundred thousand applications for patents per year, is a protector of the rights of the inventor and the foundation upon which American agriculture, commerce, and industry are based. The patent system has been one of the main streams upon which American inventive, engineering, and scientific talents have reached harbors of great achievement.

Bureau of Mines develops efficient methods of mining and of ore treatment and utilization. It is the source of fundamental information relating to coal, metals, and oils.

Coast and Geodetic Survey — surveyor of oceans, gulfs, lakes, and bays; the charter and marker of coast lines; the sounder of the depths of waters; the predictor of tides and earthquakes.

Bureau of Fisheries — propagator and protector of every species of fish in American waters to meet the ever-increasing demands for edible fish, shells, and fish oils. The fishery products of the United States amount to over $80,000,000 annually; made possible by scientific methods of producing, harvesting, freezing, and transporting fish and fish products.

Steamboat Inspection Service — inspects the hull, life-saving equipment, fire apparatus, boilers, and machinery, on ships carrying passengers from ports of the United States except those of countries having reciprocal inspection with the United States. Fundamentally an engineering service to protect the lives and property of American citizens.

Bureau of Aëronautics — a recent addition arising from the development and use of the airplane. It is extending to commercial aviation those aids which the Federal Government from its inception has extended to navigation. This Bureau was established in 1926 with an appropriation of $550,000. In 1930–31 it will spend $8,925,830.

Bureau of Foreign and Domestic Commerce — the master salesman of American commerce and industry, with representatives in every part of the world. There are some twenty commodity divisions giving special attention to the marketing of manufactured products such as agricultural implements, automobiles and parts, boots and shoes, chemicals, coal, electrical equipment, and food-stuffs.

The growth of the Department of Commerce has been phenomenal. It was organized as the Department of Commerce and Labor in 1903, but was made a separate entity in 1913, with an appropriation of $11,275,977. Today it employs 17,503 and will spend in 1929–30 $58,459,749. There is being erected for it the largest office building in the world at a cost of $17,500,000, containing 1,093,000 square feet of floor space.

DEPARTMENT OF LABOR

The function of the Department of Labor is to promote the welfare of wage earners. This is a relatively new department the need for which arose from the growth of American industry. Some measure of the influence of industry upon the activities of the Department is the relative number of wage earners employed by industry. In round numbers there are 42,000,000 wage earners in the United States of which number 14,000,000 are employed by industry. This industrial employment requires the Department to study constantly all phases of accidents and their prevention; occupational disease, their causes and prevention; the ebb and flow of employment; the cost of food, clothing, and shelter. To secure information with respect to employment alone requires receiving reports from over five thousand representative establishments in forty-three manufacturing industries.

INDEPENDENT ESTABLISHMENTS

In addition to the ten great executive departments there are fifty-four independent establishments which report to the President. Many of these came into being because of engineering and industrial development.

The Interstate Commerce Commission administers the Interstate Commerce Act which applies to all common carriers engaged in interstate commerce. This Commission is a direct outgrowth of the development of transportation agencies. Among other things it is concerned with the design, construction, maintenance, operation, and value of equipment used in the interstate transportation of persons and property. The Commission is likewise charged with responsibility concerning all instrumentalities and facilities used in connection with the transmission of intelligence and messages by the use of electric energy.

Federal Trade Commission — chief duty is to prevent unfair competition and the restriction of trade in interstate and foreign commerce. Since manufactured products comprise a large volume of interstate and foreign commerce it can be said that the need for this Commission came with the growth and spread of industrial activities in America.

The Tariff Commission — among other duties the commission determines the cost of production of similar commodities made in the United States and abroad, for tariff-making purposes. This is done in order to protect American industry and wage earners from foreign competition. It is fair to say that were it not for the industrial development of this and other countries such a commission would not have been created.

The Federal Power and Radio Commissions are new engineering features of the Federal Government. One exists because of the important and large scale development of hydro-electric power, the other because of the radio, both recent engineering achievements. They are of great value to the masses and mark a new era in the life of mankind.

Among the independent establishments there are twenty-four which are directly engineering in character and show the varied and penetrating influence of engineering and science upon governmental activity:

National Academy of Sciences
Interstate Commerce Commission
Bureau of Efficiency
Federal Trade Commission
U. S. Shipping Board
U. S. Railroad Administration
Aëronautical Board
National Screw Thread Commission
Nicaraguan Canal Commission
Panama Canal Commission
Federal Power Commission
U. S. Geographic Board
International Joint Commission
Inland Waterways Commission
International Boundary Commission
Federal Board of Surveys and Maps
Commission on Navy Yards and Naval Stations
Board of Road Commissioners of Alaska
National Advisory Committee for Aëronautics
National Capital Park and Planning Commission
Rock Creek and Potomac Parkway Commission
Federal Oil Conservation Board
Federal Radio Commission
Office of Chief Co-ordinator

None of these was in existence in the time of George Washington, and almost all have been constituted within two decades.

THE CONGRESS

The Senate

The United States Senate delves into matters of state and debates the League of Nations and the World Court. However sedate it may be in all these matters, it cannot escape the musical whirl of the machine age. Frequently it must turn its attention to the vibrations of the atmosphere, the handiwork of the engineer. Consequently, of the thirty-three committees of the Senate twenty are concerned with those things from which result food, shelter, clothing, and national security. These are:

Agriculture and Forestry
Appropriations
Civil Service
Commerce
Education and Labor
Immigration
Indian Affairs
Inter-oceanic Canals
Interstate Commerce
Immigration and Reclamation
Judiciary
Manufactures
Military Affairs
Naval Affairs
Mines and Mining
Patents
Post-Offices and Post Roads
Printing
Public Buildings and Grounds
Public Lands and Surveys

The House of Representatives

The House of Representatives has forty-two committees of which twenty-four are concerned with questions arising from this so-called machine age. A brief résumé of the functions of these committees is sufficient to show their relationship to engineering and industrial progress.

Appropriations — gives careful consideration to and recommends appropriations for the extensive and varied scientific, engineering, and commercial activities of the government.

Judiciary — one example will suffice to illustrate how modern industry and engineering play a part in the work of this committee. The contractual relations of the Federal Government are complex and multitudinous. They cover the purchase of all sorts of services, materials, and equipment. For some years there has been pending before this committee a bill proposing a thorough revamping of the contractual practices of the government. No more important bill has been before this committee in years.

Coinage, Weights, and Measures — the name of the committee significantly indicates the scientific and technical character of its work.

Interstate and Foreign Commerce — the discussion of the activities of the Department of Commerce, the Interstate Commerce Commission, the Federal Trade Commission, and the Federal Radio Commission indicates how the work of this committee is influenced by engineering development.

Rivers and Harbors — determines upon what rivers and harbors are to be improved and specifies the total amount to be expended annually.

Merchant Marine and Fisheries — the development of a merchant marine involves the use of engineering materials, equipment, and services. The Bureau of Fisheries, fostering the fish industry in all its aspects, is largely responsible to this committee.

Agriculture — the Bureau of Public Roads, the Forest Service, and other engineering phases of the Department of Agriculture, come under the direction of this committee.

Military and Naval Affairs — the engineering considerations with which these committees deal include materiél, ordnance, explosives, aircraft, cruisers, submarines, radio, and industrial preparedness.

Post-Office and Post Roads — the name of this committee suggests millions of pieces of material in the form of letters, papers, parcel-post packages, mail cars, automobiles, airplanes, ships, and buildings.

Public Lands — natural resources, coal, oil, water, minerals, wood, irrigation, and reclamation, all connote engineering.

Indian Affairs — the Indians own land, oil, coal, and water, and they present a large personnel problem.

Mines and Mining — deals with questions affecting the location, production, refinement, use and conservation of mineral resources.

Public Buildings and Grounds — when this committee is mentioned there at once comes to mind the construction and repair of Post Offices, Court and Custom Houses, Embassies, the Congressional Library, the Capitol, and the White House.

Education — suffice to recall the Morrill Act and all subsequent acts pertaining to the establishment and operation of colleges of agriculture and the mechanic arts.

Labor — the safety, health, and general well-being of the 42,000,000 wage earners are directly affected by the work of this committee.

Patents — over a million patents have been issued by the Patent Office. In a large measure the Patents Committee has shaped the fabric of this great service.

Civil Service — specifications, rates of pay, conditions of work, longevity, sick and retirement allowances for government employees, including all men of science are the concern of this committee.

Irrigation and Reclamation — the name of this committee suggests arid lands converted into productive oases through the handiwork of the engineer.

Expenditures in the Executive Departments — one of the important functions of this committee is to consider bills relating to government reorganization. In 1928 it held extensive hearings on a bill providing for a Department of Public Works.

The Census — guides the Bureau of the Census which in its next report will give special attention to the important question of manufacturers, distribution, and unemployment.

Roads — within two decades hundreds of millions of dollars have been spent in the building of thousands of miles of modern highways, largely as a result of the work of this committee.

Flood Control — is charged with the responsibility of shaping legislation for the solution of the Mississippi River flood problem, the largest engineering project confronting the nation.

Printing — the *Congressional Record* is not the only publication printed by the Government Printing Office. This largest printing establishment in the world issues publications touching upon every phase of human life. This committee is the board of directors of a very large manufacturing enterprise.

From the foregoing it is obvious that many of the committees of Congress deal with questions having their roots in engineering. Very naturally there issue from the committee-rooms numerous bills saturated with engineering import. Some of the most important and debated bills before Congress in recent years have been of an engineering character; for instance, Muscle Shoals, Boulder Canyon Dam, Flood Control, Government Reorganization, Radio Broadcasting, and Public Utilities.

THE PRESIDENT

THE President of the United States, being the chief executive of the Nation, is responsible for the effective and efficient operation of the Government. Hence he, too, must give personal attention to the many and important phases of government grounded in engineering and arising from industrial development, he must use the power and influence of his high office to mitigate the ill effects of any national catastrophe.

This he did in connection with the recent stock market débâcle. He held a series of conferences with the leaders of business and industry to determine what might be done to continue operations on a scale which would in a large measure offset the effects of the unprecedented drop in stock values. Due to the contribution of engineering to organization, rapid means of communication and transportation, and to well-developed agencies of fact collection and analysis, in the span of a very few days a comprehensive picture of the state of commerce and industry was obtained. Never in the history of the world was so much fact material developed and presented in such a short interval of time. This accomplishment could not have been realized twenty-five or thirty years ago because the necessary engineering and mechanical progress had not then been made.

The conferences of the President soon developed that the most immediate and promising means of stabilizing business was through engineering works. The railroads announced an anticipated expenditure during 1930 of $1,050,000,000 for grade and track improvement, for new cars and locomotives. The public utilities, meaning the electric light and power, manufactured and natural gas, and electric railway companies, said they would spend for new construction and maintenance, $2,100,000,000. The construction industry reported an expected expenditure of over $8,000,000,000 for new work and $2,000,000,000 for remodelling operations. The steel industry announced it would spend $500,000,000. An expenditure of $1,550,000,000 for public works by the national, state, and municipal governments was announced.

When the facts were collected and analysed it became evident that the anticipated expenditures for engineering, industrial, and public works were so large as to assure a promising business outlook. Thus the Federal Administration was enabled to assure the people of the nation that they might proceed about their daily tasks with confidence.

It is not desired to claim more credit for engineering methods and approach than they are entitled to. However, it is a fair question to ask, since such a thing had never been done before by the chief executive of any nation whether in this instance, it would have been accomplished so effectively and in such a manner had the President been other than an engineer.

THIS review of the activities of the Federal Government while not exhaustive, clearly shows that a very large fraction of the expenditures, personnel, and effort of its executives and legislators is devoted to matters arising from engineering development and its influence. This same condition prevails in state and municipal governments. The legislation of the greatest moment and of the most direct concern to the people of the several states is predominantly engineering in aspect.

The great problems confronting American cities are of an engineering character. Some of these problems are water supply, sewage disposal, transportation facilities, traffic regulation and control, building regulations, street improvement, smoke abatement, and so on, ad infinitum. So pronounced are the engineering considerations that new forms of city government are being set up to deal with them. The city manager plan, or some modification thereof, is rapidly spreading throughout the nation. Some

300 municipalities have this form of management and approximattely 75 per cent of the city managers are engineers.

INFLUENCE OF NEW TECHNIQUE ON POLITICAL METHODS

The foregoing has indicated that engineering technique and the results thereof have permeated the entire structure of the Federal Government. It has been shown that many of the Executive Departments and independent establishments, the Congress and the Chief Executive himself are required to devote a large portion of their time and effort to the consideration of matters arising from engineering and industrial development. It has also been indicated that in order to meet these demands, the Government has a large number of technical men on its permanent staff and from time to time employs expert consultants. In view of such conditions it would be natural to expect that political methods have not escaped such influences and that they reflect such.

The presidential campaign of Andrew Jackson was unique in at least one respect. It was the first time in the history of this nation that newspapers were designedly and widely used as a means of reaching and influencing the voters. Jackson's success in his campaign has been attributed to the interest aroused in his behalf through the newspapers. Thus a hundred years ago the product of machinery, namely, the newspaper, was used as an important political agency. From Jackson's day to the beginning of the last decade the newspaper continued to be one of the primary methods of reaching the voters in political campaigns. Then another scientific and engineering development was brought into play. During the presidential campaigns of 1920, 1924, and particularly 1928, the radio was largely depended upon, not supplanting the newspaper but supplementing it very materially. There have been a number of instances in the last decade when the chief executives of the nation as well as of the several states have gone directly to the people of their respective political areas through the instrumentality of the radio. It is known that preparations are now being made whereby in the next presidential campaign the radio will be used in ways and to an extent not heretofore thought of. Probably there is no other instrumentality that has or will more largely affect political methods than the radio.

To radio broadcasting there will be added television, whereby large numbers of American citizens may sit in their homes and both see and hear political speakers. The ability to reach the sight and hearing of millions of voters through the instrumentality of the radio will have a profound influence and may well change the entire trend of political thought of the nation.

THE ENGINEERING PROFESSION

THE engineering profession has been aware of the impress engineering is making upon political and governmental affairs. It has realized that, since the handiwork of the engineer is in a measure responsible for the trend of events, the profession has a particular duty to meet. The profession has been conscious that as citizens, the engineers had not fully discharged their duty through making available engineering methods and equipment; therefore they should provide a definite means whereby their training and experience might be placed at the service of the government and of the nation.

This led to the formation of an Engineering Council in the spring of 1917. This Council was organized on a restricted basis which was soon found to be inadequate. Consequently a reorganization took place in 1920 at which time American Engineering Council came into being. Council began to function in 1921 with the Honorable Herbert Hoover as president.

In the Constitution of American Engineering Council, the profession stated that "The object of this organization shall be to further the public welfare wherever technical and engineering knowledge and experience are involved and to consider and act upon matters of common concern to the engineering and allied technical professions." In the Preamble of the Constitution, is this statement: "As service to others is the expression of the highest motive to which men respond and as duty to contribute to the public demands the best efforts man can put forth, now therefore the engineering and allied technical societies of the United States of America, through the formation of American Engineering Council, realize a long cherished ideal — a comprehensive organization dedicated to the service of the community, the state, and nation."

This organization has been functioning for nine years in full accord with the tenets laid down in its Constitution. It represents 57,000 of the leading professional engineers of the nation who unstintingly give of their time and effort, to the solution of public questions of an engineering character.

The sole motive of the engineering profession in operating American Engineering Council is to assist the Federal Government in every possible and legitimate manner to more adequately and effectively deal with the engineering questions which confront it. The mere existence and operation of such an organization is a manifestation of the realization of the many perplexing engineering questions with which the Federal Government must deal. It also indicates the realization that state and municipal governments likewise have many questions of a similar character because the organization is dedicated not only to the service of the nation but of the community and state.

There exists in a number of the states, state engineering councils organized somewhat upon the same basis and for the same purpose as American Engineering Council. They are designed to do in their respective states what the Council is endeavoring to do in a national way. These movements are significant and they suggest that as time goes on engineers will play an increasingly important part in national, state, and community affairs.

COULD A COUNCIL OF ENGINEERING EXPERTS OPERATE A GOVERNMENT SUCCESSFULLY?

THE facetious and ironic might be inclined to say, since engineering enters so largely into the activities of the Federal Government, why not establish a council of engineering experts to operate the government. The engineer would be the last to claim that the government could be successfully operated by a council of engineering experts, because he is a man who bases his decisions upon facts. The fact is that no modern government can operate successfully without expert guidance with respect to fiscal, legal, and legislative affairs, public welfare and works, national defence, commerce and trade, and foreign and domestic relations. While there has been some appreciation of these several functions and while the governmental organization to a degree takes note of them, yet in a very large measure they have been disregarded. As a consequence the government has grown to large proportions without design or plan. For instance, the agencies dealing with the conservation of natural resources are distributed among five departments. The activities of the Federal Government with relation to public works are found in ten executive departments and independent agencies and thirty-six bureaus, offices, or commissions.

The engineering profession has long recognized these undesirable conditions. Intermittently, since 1881, it has advocated that, in so far as the public works functions of the government are concerned, they should be concentrated in one department, thus recognizing the "major purpose" idea in organization. This line of thinking and effort is in keeping with the thought expressed by the President in his message to Congress, when he said, "It seems to me that the essentials of reorganization are two in number. First, all administrative activities of the same major purpose should be placed in groups under single-headed responsibility; second, all executive and administrative functions should be separated from boards and commissions and placed under individual responsibility, while quasi-legislative and quasi-judicial and broadly advisory functions should be removed from individual authority and assigned to boards and commissions."

In accordance with this principle, engineers would not advocate a council of engineering experts to operate the entire government, but they would advocate the equivalent to a council of experts for each of the major functions of the Federal Government. The engineering and allied technical professions have consistently taken the position that it is neither economic nor effective, to have the responsibility for the public works functions of the government distributed among ten executive departments and thirty-six sub-divisions thereof. The best engineering thought is that all of the engineering, architectural, and construction work of the Federal Government should be concentrated in one department.

This organization plan would not only beget a greater effectiveness in the experts in the several branches but it would bring about a degree of co-ordination and co-operation that is impossible under present circumstances, and would result in more efficient and economic operation. Again, such an organization would be entirely in line with what has been accomplished in the realm of industry. It would in a sense be equivalent to injecting into the government those engineering and industrial principles of organization and operation which have been so effective in other lines of human activity.

X — ART IN THE MARKET PLACE

The Industrial Arts in the Machine Age

By Richard F. Bach

I

ART IS here in goodly company. Since the present volume has grown out of a suggestion made by engineers it would seem both necessary and obvious that, in dealing with the cultural potentialities of life today, it should include a discussion of the tendencies toward civilization revealed by architecture. That the industrial arts should also be invited to sit with invention, business, transportation, communication, and engineering — all of which help to produce them and in turn are improved by them — is a departure to be regarded almost as insurgency. Not that the industrial arts should be classed with engineering or technology, but that without engineering and technology the most ordinary objects of daily need, use, and satisfaction, not omitting numerous items of special nature as well, would not be available at all to that average man, whom the columnist with bland adequacy describes as generally much above the average. These things out of which are composed our home environment, our apparel, our pleasures, and countless other facts and incidentals of comfort and contentment, not to mention of health and work, these "artifacts" that reflect character, betray taste, and constitute the background if not the soil of culture — all of these are made, conveyed to us, and brought within reach of the limited purse by mechanical means.

In many places in this book appear the words machine civilization; they have been repeated in hundreds of other books, they have served for years as the meat of sermons and the cream of lectures; they have been an essential ingredient of all discussions of American life, for without them it would have been too easy to prove that American social progress is something more than an allegation. Analysed to the end they have the psychologic appeal and advantage of contrast, nothing more, for the words machine and civilization at one time seemed to have very little in common. To be sure, at one time that seeming was fact. With the aid of remarkable writers like Ruskin, himself a congeries of contrasts, and of even more amazing artists like William Morris, whose misguided preaching sought to achieve progress through wilful, indeed controlled, retrogression — but did not prevent him personally from producing splendid results in a dozen crafts — the feud between civilization and the machine, as this affected the arts, was given a momentum that is still the propelling force behind the utterance of numerous publicists; notable among these are the European observers who take advantage of every mechanical means to save time and energy in order to be able to tell us later how little time and energy we save by mechanical means. Meanwhile the machine hums merrily on, doing more in the space of a half-dozen decades to help and hinder art, than all the religions of a score of racial cultures have done in twice that number of centuries. Nor is this the exaggeration of panegyric.

The broad philosophy and alluring romance of machinery and its integral relation to life are elsewhere set forth; its relation to the industrial arts, as art, will not have been mentioned. Less yet is the chance that any comparison will have been made between, let us say, the cultural importance of a hand-made chariot such as only Publius Romanus could drive in ancient Rome — for did he not have twenty triremes plying from Ostia to Jaffa? — and the little Ford that even Smith and Jones and others composing the legions commanded by "the man in the street" can afford to drive, and by means of which erstwhile remote centres of trade, culture, and entertainment are brought within the radius of one or two gallons of gasolene.

The car is a product of industrial art, as once were the chariot, the buggy, and the coach. But then they were made with hand-driven tools and could occasionally lay claim to the distinction of art; now they are made by machine and even without claim are credited with every kind of performance except that of rendering artistic satisfaction. This situation was long ignored or remained unrecognized, but it is being improved now as rapidly as good sense and good business, better education and better taste can bring their remedial influences and work into range. But none of these, nor all in unison, can accomplish the desired result without reliance upon quantity production.

II

Quality, style, beauty, art: these, which are one, are not themselves things; they are like an intangible coloring medium in a liquid or like leaven in bread. The material is different for their presence, becomes usable, gives satisfaction or pleasure. Referred to one object, to a single rug, a single ring, the task and the test are simple. Referred to the mass of people who want and have a right to own rugs and rings, the simple problem of pleasing an individual becomes a gigantic job in economics and sociology. How can art better play its rôle as educator, inspirer, emotional stimulant, than in bringing the best possible standard of design to the "cross-section of the public" in the broadest sense, to the ordinary consumers? And that not only in Callot gowns and custom coach-work by Fleetwood, but rather in Woolworth jewels and bodies by Ford; in comic strips, lampshades, soap wrappers, bath tubs, kitchen utensils, refrigerators, clothing, handbags, fountain-pens, percolators, metal beds — all this in addition to the time-honored forms of furnishings for house and table. This must mean, again, the machine, the machine as maker and purveyor both of material and of utility, but with the invariable condition that these be improved by a creative instillation of design from which alone derives their form and appeal.

Nevertheless some seek to justify the existence of the machine and, especially in relation to art, to reconcile it with civilization. Among these the first to praise its value in other walks of life are also the first to deride the machine as an aid in producing art. That despite the overwhelming display in department stores, the fabulous resource of advertising and the general availability to everyone of so many objects of daily use in always more attractive garb, the machine should still seem to be in need of justification is amusing. One does not justify Niagara Falls. The machine in our civilization is a social fact, a reality; it is here, it will stay, in industrial art as well as in agriculture. We have to reckon with an immeasurably valuable tool of life, supplying with very few exceptions the whole category of our requirements in the way of food, clothing, utensils, shelter, conveyance, amusement, adornment. Everything from pastry forms to plowshares must feel its touch. An implacable and now irreplaceable force, it must be controlled, exploited, used, or it will grind to destruction both its maker and itself. Fortunately it *is* being used to prodigious advantage, for it was brought into existence solely for use by men who had immediate need for it, and not a few of whom worked in the industrial arts. Offspring of economic pressure, the machine had, definitely, the purpose of economy in the narrow sense of saving: saving time, saving money, saving labor. It has done all these things — thus far less for art than for industry — with promise of endless extension of its capacities, the while reacting upon its creators as a pace-maker, unable to outstrip them yet seeming to drive them to always greater accompishment. Its potentialities have been barely touched; they are limited only by human genius and invention, and before the general use of the word industry artists were proud to be credited with invention. The machine is a tool; it can never be more.

III

But even as the tool in the hand reveals to the craftsman constantly new possibilities beyond the intention and hope of its user, so the complex mechanism which feeds on oil and coal and electricity likewise shows itself repeatedly as a silent partner in invention, ingeniously uncovering still further reaches for designer as well as technologist to explore. The machine is a maker of both products and values, including those of art, so powerful that it is itself a value, a vast economic value, which has imposed itself upon American life as a characteristic for all time and threatens now to place a similar stamp upon Europe as well. The machine has not made of art a concept comprehensible to the mass: that is the province of education; but it has surely made available to the mass a myriad objects each in some way a vehicle of art and a contributor, however undeveloped, to culture.

For the machine itself is a design, a conscious effort to make, fit, adjust, or bring into relationship certain working elements to meet a specific purpose. The process of its devising is creative, as is the process of devising forms to achieve the emotional reactions some of us experience before an object of art. This creative intention must be recognized as the broad base upon which rest the similar but not twin temples of art and science, with between them a third, somewhat resembling each of the others, housing priests who study somewhat of both creeds; its doors stand wide for those willing to confess themselves industrial art designers, manufacturers, or purveyors as well as for the numberless ordinary folk who must have tea-cups and hats and living-room chairs, and who in token of their belief buy these things with always greater taste — a quality which has been defined as discrimination many times exercised.

The time is past when any group, class, caste, or clique could hold a monopoly of art, assume the possession of taste and dictate the course of style. Modern distribution of the industrial arts has definitively removed all opportunities for the hierarchic control of art; even fashion keynotes are now struck much lower in the social scale.

IV

IT MAY to some ears still sound apocryphal, but there is no blinking the fact that the machine — using this term as emblematic of modern industrialism — is a leveler and, as such, an instrument of democracy. Out of the opportunities it has offered has grown a considerable increase in the rights of men as individuals. Formerly they had the right to enjoy art as they saw it in public or private architecture and in church decoration or as they heard it in liturgic music. Beyond that they had their folk arts of costume, decoration, dance, and song, which the growth of cities and the improvement of communication — again aided by the machine — has practically destroyed. But ownership of objects of art was limited first to home crafts and secondly to a few things to which cost and labor contributed that intrinsic value that we now too readily regard as one only of sentiment. In the family or homestead the heirloom was first of all an economic factor to which sentimental values were bound to attach themselves because of association, history, or habit.

Today the individual may own an endless number of objects of industrial art. The trappings of his saddle horse are now the inexpensive automobile; in place of one chest, a few chairs, a plain table and bed, rough walls and rougher floor, he has today much more elegent possibilities both in kind and number of pieces of furniture, and as a rule is able to supplement them with rugs, curtains, wall paper, lighting fixtures, prints, not to mention various important items of utilitarian equipment also susceptible to artistic treatment. In place of ecclesiastic decoration or rare works in print, which certainly never were aimed at earthly happiness, he has today the resource of numberless inexpensive volumes with just that fillip, of the illustrated magazines and daily press cartoons, of the motion picture, and of that demigod of the twentieth century, advertising, which demonstrates a thousand times a second that a picture is worth an incomprehensible number of words.

The machine has brought these many possibilities not only within range of the eye but also within reach of the hand. It may well be asked: for good or evil ends? Do these possibilities all constitute advantages or hindrances; do they edify and educate, or do they clog the channel of life? These are matters for speculation and prophecy, which in considerable measure this volume offers; but the judgment of the living by the living is beset by so many frailties that the difference between prophecy and surmise will be difficult to distinguish.

We have really to deal with a sometimes dismally factual situation, in which the simple apartment dweller and subway rider is as important as the wealthy patron of the most recently touted vorticist painter. The fact remains that the increasing availability of relatively inexpensive objects for home environment, apparel, transportation, and other latter day requirements, which has been brought about by the machine, has at the same time accustomed us to expect much more of life, notably in the form of working ingredients, *things*, some inert, some as substitutes for human energy, but all conceived first as useful and then as attractive. Since these expectations have been progressively realized in an always larger number and over an always increasing area, both territorially and in terms of our real or assumed needs, they have gradually been translated into demands, inarticulate, indefinite, but insistent. The demands in turn could be met only by rapid-fire invention and quantity production of these multifarious objects of industrial art. To own them is no longer a privilege, but a necessity, and our status as members of society is largely measured by our ownership or use of necessities which our parents regarded as sheer luxuries and which our grandparents might have regarded, if thought of at all, as good material for novels of mystery and prophecy.

By way of example, consider the course of invention and its logical sequel of improvement in appearance which has characterized the cook-stove or the house furnace that heats even the small cottage, the automobile, the vacuum-cleaner, the camera, the typewriter, the phonograph, and various forms of radio furniture, cartons and containers of paper, tin, and glass that crowd the shelves of some two million stores in our country alone, sport clothing and paraphernalia generally, overshoes, metal furniture, sewing-machines, lighting fixtures, and scores of building and decorating materials. That science and technology should contribute heavily to the resources of the industrial arts was a foregone conclusion; that in these resources fresh opportunities for design would quickly be uncovered was also to be expected; though achievements in this direction offer daily the most fascinating surprises. The results are most impressive, appearing notably in textiles, in paint and other coloring mediums, in processes of reproduction, in construction, and in illumination. Thus experiment and empiricism have both aligned themselves with the artistic purpose.

V

MEANWHILE another giant, one of elemental vigor, has grown to an overbearing adolescence. Business in a new panoply now stands between us and the manufacturer: the business of selling. Like many another simple English word, selling requires a new definition to fit the new age. It describes today a very complicated procedure for which the word distribution seems a better term. But in relation to the industrial arts selling has taken from manufacturing its power and authority as interpreter of public interest and demand. The store has become the barometer of public taste in industrial art. The primary emphasis might be assumed to rest on the exchange of goods for cash; but a transaction so simple is no longer acceptable in the modern store, where this exchange seems to the initiated nothing more than the closing gesture of a long and well-prepared process. The store's machinery of selling is finely geared and, apart from studying its costs like any other business, it has still another task: beyond all considerations of materials, utility and price, its offerings must please the eye.

Since with few exceptions the merchandise is all machine made months in advance, there must be brought into play the most skilful methods of forecasting and anticipating the interests of the buying public. For the store stands between maker and consumer: toward the former it functions as editor, toward the latter as publisher. Thus it has the opportunity, and withal the very heavy responsibility, of helping the public to obtain good design. The emphasis on price will never disappear, but in very recent years the emphasis on design has handily stepped back into its historic place among the points to be featured in making a sale. Thus the appearance of an upholstery fabric, for example, is no longer an ancillary consideration; it counts equally with durability and with price in determining the value of the material as merchandise.

In view of the high-pressure selling methods generally employed and indeed necessary today quantity production finds in the store a powerful ally and for many products its primary outlet. Stores assure a ready flow of factory products to the public, thus providing for the producer as well as the consumer an economic safeguard of immense value. The factory knows better what to make, the consumer in turn is confident of wide choice and, within reason, of low price as well.

Considering the myriad products which without some form of artistic design would not be salable at all (though, of course, the same statement applies to factories), it is patent that the stores, in their double capacity as counsel to manufacturer and consumer at the same time, constitute a very important factor in the development of taste. Fortunately, in recent years, a fairly general movement, part of it quite honest, in behalf of better design, has got under way among them. The consumer, as a class, has certainly improved his judgment in matters of design and one likes to believe that this was the chief cause of the present intense activities of the stores in favor of art in industry.

The truth remains, however, that the store is primarily a handler of goods, a highly complicated means of selling. In the vernacular, the goods must move. Various more or less canny devices are called into play to achieve this objective, the reliance upon design among them. So that we may once more see art in the market place, for, after all, it *is* a commodity; no amount of sanctimonious flummery will alter the fact that designers and craftsmen, not to mention manufacturers and merchants, enjoy a wholesome craving for sustenance and must therefore compete for their rewards.

But the store grows chiefly by selling more, not only better, merchandise. To help maintain the steady increase in sales volume design is again called into play. In the guise of fashion in costume with its myriad accessories, in a thousand gewgaws classed in the trade as novelties, in fantastic special offerings, in addition to many of the so-called "staples," the store now definitely considers design first. It is the unfortunate circumstance, in the present pass, that the use is often misuse, design serving as a subterfuge in catch-penny business, in disguising poor material or workmanship, and in other ways; or the design is paraded as fine when the opposite is true, reliance being placed in this case upon a too liberal public interpretation of the popular saying that seeing is believing. The abuse of the so-called "modern art" is a case in point on both charges.

However reasonable, for instance, style in clothing may be, basically, and as the mirror of its day, wherein it shares the effectiveness of architecture, literature, and the other arts, there can be little doubt in the minds of the most ingenuous that as fashion in costume, its dizzy changes, while both fascinating and amusing reflections upon human psychology, have made greater inroads upon the domestic purse than any other necessity or luxury except food, which itself is frequently relegated to second place, as daily observation shows. Of the grand total of American money annually spent for all types of industrial art, more than half is claimed by women's clothes alone.

Needless to say the calculated fickleness in this important industrial art has been a great aid to design, for it has made heavy demands upon the artists. That it produces more of cleverness than of calibre is beyond question; that it is a game without rules, its plays seemingly prompted no more by real style tendencies than by the gambling instinct, is obvious from the heavy mortality among new models; that not as clothing, but as a series of ephemeral fashions, its vagaries must hinder the progress of other arts because contributing to an instability of opinion and a waiting for cue words from others, even from across the sea, is to say the least a troubling sidelight on the growth of art in our country, for the purchasing agent of the American family for all types of industrial art is invariably a woman. But it sells. And the product is, of course, infinitely less important than the design which gives it the only reason for being. It is an interesting point, in the present connection, that costume and clothing are not interchangeable terms: the qualities most essential in clothing considered as garments, are the least important in garments considered as costume.

There are a number of other seasonal art industries, and seasonal changes in many more; they all count on design to carry their work to success. That this is now done more constructively, with more regard for the principles of design as applied in the arts they exemplify, and less in the manner of repeated rearrangements of time-worn motives from pattern-book files or handbooks of ornament, is a hopeful sign, for it indicates that we are no longer engrossed in the machine as a techincal toy, that we see the industrial art product in terms of its chief appeal, namely, design, and that we employ the machine as a tool to realize the design, not merely to manufacture an object.

VI

It has been said that mechanical production, in combination with heavily advertised large-scale selling, can inundate the land with ugliness, stultify taste, starve productive imagination, immolate art as a burnt offering upon an altar of wheels and sales checks. We are told that the nineteenth century in its second half nearly achieved this end, failing only because advertising and adequate selling organization had not yet been developed to full strength.

The question engages many minds; and not a few declare the gruesome picture of such an arid era fully realizable, possibly after calamity has numbed human desire for the satisfactions to be got from art. The interest in art can be dulled, thwarted, diverted, or become atrophied; it cannot be eradicated. Should an intensified nineteenth century pall again descend upon us, there would come, much quicker than then, a resurgence of desire for better design. We are in the midst of such a resurgence now.

Again, though there may be some doubt as to how much we know about the machines we have invented, there is no doubt that we are less and less dazzled by them; we see them as instruments, not as automata. If art in industry is headed for another slump the machine may be a contributing factor, it will not be the cause. Nor, incidentally, was it the cause in the nineteenth century débâcle of the industrial arts. On the other hand, should the awful opportunity present itself, as above suggested, and business in the triad of manufacturing, advertising, and selling had not public taste in industrial art in the form of a "buyer's market" to contend with, there is no question that business would take full advantage of the opening and "dump" whatever was readiest to hand. Business is not a builder of culture; though its profits have provided cultivation for multitudes, in museums, schools, and other opportunities for education and for emotional stimulation.

But business has provided a whip to keep itself in line. Competition in industrial arts manufacture is as keen as in any other field; fabrics compete on the basis of good artistic design, steam shovels on the basis of good mechanical design. Competition is at present the strongest ally of design in its effort to rehabilitate itself, for competitors are using art as a big gun in their attacks on "consumer preference." Wisely used, competition becomes a guarantee that the integration of art and industry is once more assured.

Then there is the further reliance to be found in the growing body of public opinion in favor of good design. This is the best safeguard that could be established, for the industrial arts consist primarily of necessities. But we have no proof that public opinion is a sufficiently constant force; nor is there any reason to expect it to be more constant in its art interests than in other directions in the present state of culture. It may, often must, respond to other incentives, take from one demand to meet another. The art interest can be charted as a continuous line of varying width in waves of varying height. We are now upon an ascending wave and the line is growing daily wider. All educational agencies need to exert themselves, nevertheless, to keep public opinion alert and to make it capable, for the inveterate grind of the machine goes on, and it can be turned toward good as easily as toward evil. The lever of design works both ways.

But it will be said: machine production brings uniformity of objects of industrial art, which must perforce bring uniformity of life; this in turn makes for monotony which is, spiritually, a synonym for progressive degeneration. The answer is that the machine has been producing furniture and other industrial art products in recent decades in greater volume than ever before, and that during the same period of time design has been improving steadily and rapidly; secondly, that competition again introduces variety; thirdly, that a cursory acquaintance with the great American family will reveal a surprising amount of well-established uniformity in thought and action, of which quantity-produced furniture and other necessities may as readily be an effect as a cause. No, a good design does not suffer by duplication. We are repeatedly told that the craftsman of old could not duplicate his models. No doubt some would not; but for the rest, we may count upon human nature to make it possible to produce duplicates if duplicates were ordered. The craftsman was in the business of producing industrial art. The real importance of the craftsman of old is to be found not only in that he made fine things, but also in that someone bought them.

VII

AND what of handicraft today? Quickly answered: the machine has destroyed it. To this there is the corollary disturbing to some: are not hand-loom and potter's wheel also machines?

The disappearance of handicraft as a variegated industry was due to economic causes. The machine saved time, labor, money and did this so thoroughly well that the simplest folk arts even among aborigines in forest depths have succumbed to its greater accuracy and to the low cost and quick availability of its products. In the folk arts the emphasis is not on art. The machine, on that side, destroyed very little art, but it did remove the opportunity for self-expression which the varied skills included in these home-crafts presented. The loss has not thus far found a constructive compensation, except possibly, in slight degree, in sports.

Very little that we own, from doormat to roof-tile, is now made by hand. What has become of craftmanship as a human capacity? Craftsmanship is a quality which may reside and be effective in a group of specialized workers, provided always that there is a designer among them, just as readily as in a single person whose mastery must be accepted as complete, because a group of his compeers have so proclaimed it.

We have today a goodly number of shops in which craftsmanship dominates a plant organization, highly specialized, using power-driven machines, yet making unique pieces. The modern craftsmanship demands greater resources, greater abilities, greater knowledge than a single mind can compass. As quantity production becomes standardized, the modern craftsmanship — *quality production* — becomes specialized. We may feel safe in looking to these smaller highly organized groups of experts in their workshops for stylistic guidance in the industrial arts. However, craftsmanship, as a personal performance, has so many advantages that it will not die out; in fact, we may with reason cherish the hope that in the course of time more and more hardy souls will breast the tide and emerge as designers, in the material itself, to replace so-called paper designers in the factories. Perhaps then the adjective mechanistic will cease to have editorial value.

VIII

SURELY if a civilization may be militarized to the extinction of life and religionized to the subugation of spirit, it can only gain in the end by being mechanized to the conservation of both. In all its mundane literalness, then, the machine as producer of industrial art is no longer external to our culture. Which is another way to say that persons who enjoy the pleasant anæsthesia induced by the worship of antique furniture will undoubtedly continue to purchase machine-made curtains, nevertheless, and sip tea from cups produced at the rate of so many hundred dozen per regular union day.

Loom and lathe will never destroy fabrics and furniture, any more than phonograph and radio can destroy music. The quality of the instruments is the gauge. For all of these are only mechanical agencies for translating or conveying ideals, and, as such, merely extensions of the hand.

Civilization, implying cultivation, sets its course by ideals. The welter of mechanism with which we have surrounded ourselves is so foursquare, noisy, and solid that the ideals sought are obscured. They are nevertheless there. Referred again to the industrial arts our machine civilization has to its credit certain very definite practical gains, as well as certain spiritual advantages. New machines and new materials have not been devised for themselves; with them new effects in design are wrought and better designs are brought within reach of more users.

On the practical side, then, we are aware that in our machine age benefits are extended freely to the many though in other days they were the special privilege of a few and these best classed as non-producers. The inventory of household goods possessed by any one of the army of commuters that New York daily scatters to its environs would represent to his social counterpart, such as a little bourgeois of Paris two hundred years ago, a fabulous affluence that a lifetime of labor could not hope to purchase.

If in the democracy of today, which Wells defines as a transitory confusion, the simple citizen can surround himself with a greater degree of elegance and comfort than ever before, this also is to be set down among the spiritual things machine civilization has made possible, for it has amplified his life, increased its resources, and released time for leisure.

In the machine age, art can no longer remain impervious to the values of time and labor. Mechanical production of spoons, chairs, and watch-chains saves both and reduces cost as well. Those are chiefly practical, but partly also ideal, objectives. Utility is the fervent gospel of the age; the industrial arts begin with utility. Every style in the history of art has attacked the age-old problem of making useful things attractive. This is a universal ideal, but in the period of mechanical production its significance has double emphasis.

The machine, more simply, remains a device, an apparatus, a tool which requires control; it does what it is geared to do and drones as pleasantly or makes the same ear-splitting clatter whether it is reproducing for the upper level of the cognoscenti the imaginative conjury of a genius, or is simply turning out a thousand gross in a hurry of catalogue number forty-two for the cheap trade. Fact, accuracy, experiment, these cannot destroy design; they are of the essence of machine civilization, however, and can only help to obtain for us real values in our industrial arts. But the countervailing evil is not to be denied: they help the maker of shoddy as well. There will always be enough of the gullible who seek a guaranteed-as-advertised happiness in the hasty claptrap which, with equal speed and diligence, the machine likewise produces — on order.

No doubt out of this grows the repeated criticism that our mechanical advantages have outstripped our ability to turn them to full profit. Edison somewhere states that we have invented machines enough and should now devote ourselves to finding out what we can do with them. For the industrial arts this is a significant admonition; it bears immediately upon design again. That we do not know what to feed to the machine for duplication is apparent from the catalogues of nine out of ten manufacturers. It is the spiritual side that Edison had in mind.

Ugliness is not a machine product; nor is beauty. These are qualities, not things. That we have not yet achieved a uniformly high standard of beauty in our industrial arts is due partly to the youth of our culture and partly to the precipitous advance of science and technology; but in practice it is a fault to be laid at the doors of makers, sellers, and users of machine products: the makers because they long abused good tools, the sellers because they have failed to recognize the sales value of good design, the consumers because they have not stood their ground and insisted on attractiveness as an asset in the objects they have purchased. On all of these counts the charges have been heard, but the culprits had already begun to mend their ways, having been advised that clemency is granted in the court of culture only to those who come with good design.

Toward Civilization — the caption gives us direction and should lend us hope. Loving our friends the manufacturers and merchants of industrial art, but having no illusions about them, we may say with cordial assurance: these arts are headed right. *Toward Civilization* — not full tilt astride a puffing thing of cogs and racket, but in a workshop inventing a complicated tool to help the artist yonder, that his flights of creative impulse may increase man's estimate of life and aid in assuring his enjoyment of it. Meanwhile art and science and technology play into one another's hands, though still with insufficient practice at the game. Omar gives us the simple question which is its own answer, and takes his example from the industrial arts: Who is the potter, pray, and who the pot?

XI — THE MACHINE AND ARCHITECTURE

By Stephen F. Voorhees *and* Ralph T. Walker

LIKE other forms of creative activity, architecture must be considered in relation to the total environment of life, labor, needs, and ideas in which it functions. It cannot flower in a desert; nor can it live on dreams of by-gone splendor. Architects may, of course, allow the imagination free range in speculation but when they design with reference to structures to be erected they must work within social and material limitations. This is inevitable. If they seek to copy and recover great patterns of other ages, still they can scarcely hope to reproduce the spirit as well as the forms of their selected models. While it is true that in the most cramping circumstances, architects enjoy a certain liberty, while by experimentation they themselves may help to give new designs to social living and economic production, the degree of their freedom will depend in a large measure upon their understanding of the nature and necessities of the civilization in which they are operating and upon their capacity to use all the devices of exploration which it affords. Hence it seems fitting that the chapter on architecture in a book of this character should deal with the stream of ideas and things presented to the architect rather than the technical aspects of the profession.

I

Now, this is the age of the question mark — an age of criticism. It might as well be called the age of criticism as the age of the machine or of science. In fact the modern time may be said to have started in the minds of men like Voltaire, Rousseau, and our own Franklin, with their desire to make over the whole world.

Criticism means curiosity, and with an inquisitiveness most acute we are taking apart the universe. Nothing is too large or too small to escape our desire to know or create. We split the molecule, the atom, and the electron. We seek the reflection of five thousand million light years. We take the pulse and the nerve throb of the vegetable, and Jove-like we play with the lightning. Keeping pace with this curiosity has been creative inventiveness, and the machine has been forced to extend our will and our senses so that our minds are free to question the infinite. The power of our hands and feet have been multiplied a thousand times. Our eyes see the unseeable, our ears hear the unhearable, and we touch the unbelievable. No one questions these great additions to our powers or the sum of our knowledge, for we have come to look upon them with a casualness that comes from familiarity with new ideas. No longer is a Galileo imprisoned or a da Vinci threatened with penalties because of ideas that are different from those held by their fellows.

Naturally, not content with our relationship to the great universe, we are also not content with our relationship to each other, and we turn the same fierce inquisitiveness upon the social world we live in, and justly so, because, as has always been the case, it can be bettered.

This self-criticism is especially an American trait, and we are both ready and willing to listen to criticism of ourselves, no matter how absurd, ill-fitting or trite, so long as the voice is both loud and assured enough. To the world at large we especially represent the civilization of the machine; our faults are blamed upon the standardization that the machine is supposed to bring; our few virtues, all of them material, are strangely enough credited to mass production. We are regimented — we all wear the same clothes; we have no manners; no cuisine because we eat canned food; no arts because we listen to canned music and see canned drama. Worst of all we are wealthy in material things and the index of living is relatively higher than it is in other countries.

The critic is generally a romantic or a pessimist, he is generally engaged in making new worlds into old. The world at present, and more so America, is a dreadful place to live in, for we have lost all primitive virtues and emotions. We are a country composed of Babbitts; spiritually we are at zero, mentally we are confused, philosophically we are too optimistic, and physically we are doomed to fatty degeneracy. Our only salvation is to agree with Samuel Butler (for it would seem that the only primitive emotion left to us is fear), put all the machines in museums and go back to the good old days, to the simplicity and primitiveness of the good old agricultural civilization. And herein lies the basis of all criticism of the machine civilization, for coupled with the desire for Utopias, the dream of all philosophers and critics is the expressed opinion that an agricultural society is much more natural, much more a part of man's true nature than is the supposedly artificial and sophisticated society which develops with the city and with which the machine is so clearly related. The criticism is actually one of a civilization that is becoming rapidly urbanized — the growing pains of which, there can be no question, are painful.

It is with this point that the architect and the engineer are interested, because primarily they are associated with urban life. It is their ability to take the human requirements and the mechanical means and so mould them to form a solution, that will make this urban civilization function in its plan. They must have a philosophy and an understanding of the human need. Their imagination must go far beyond that of mere mathematics and structure to a complete realization of what physical and mental comfort means, and in the end help produce the beauty of life that belongs to the visual, the mental, and the spiritual sides of man.

Architecture may be said to be a reflection of the age in which it is built — but it is much more than that. It often reflects the age that is to come. An understanding of its relation to the machine and its tendencies must also include an understanding of what it may do to the machine. It is primarily building for individual and community human needs, and when they show signs of changing so does the architectural development of them. To properly understand what architectural tendencies are being developed we must seek the fundamental changes that are taking place in our mode of living.

Probably the greatest change that has taken place since the invention of the machine, as we understand it, has been in the relation of the city and the country to each other. Heretofore there has always existed between the city-dweller and the countryman a divergence of thought, a difference in way of living, a difference in degree of dependence, and a lack of understanding of each other's view-points, that throughout history has kept the city and the country entirely separate entities. The city has always been more dependent upon the country, while the country life has been almost self-sustaining with practically no dependence upon the city except in a small way for religious teaching. This very dependence that is found in the city is the start of specialized effort, and we find life under urban conditions one of greater or less co-operation, and we find the greater the amount of co-operative effort the more varied the intellectual interests. It is safe to assume that true perfection in work comes from a well-developed co-operative effort.

The earliest form of co-operation in urban life was caused by the need of mutual protection and but little less, so that we find a minimum of trading and recreational conveniences in the very early cities. In modern times, the city has grown enormously in size and has become wholly a co-operative effort for realizing the mutual benefits that are to be derived from the convenience in trade, manufacture, and recreation. It is true today, as it was in Athens, that a social life has grown up in both business and recreation that depends upon the selective efforts of many parts for its success. This has resulted in the growth rather than in the decline of the average of intelligence, for the city is the focal point to which the intellectuals are drawn. In relation to the country, its work is largely mental rather than physical, as it has always been the centre of mental ability whether that of pure mind or that of the crafts, where mind and hand are combined into skill.

The dependence of the city upon the country for food and raw materials has greatly increased, but the greatest change has been in the changing relation of the country and in the loss of its absolute independence — it is no longer self-sustaining but is now dependent upon the city's products for its life.

The necessity for farm machinery, for the new methods of transportation both for people and produce, for cheap electrical power, for the rural free delivery of the city's products, and for recreations such as the radio and the movie provide, has brought the country closer to the city in understanding, so that the differences in both thoughts and living are fast disappearing. It is interesting to note that even when a tendency is evident for the decentralization of the city to take place, the urban population takes into rural communities the city's method of life. Naturally any such removal of social contrasts has had, and will continue to have, the effect of a broader standardization in mode of living, and we shall expect to find that both urban and rural life will be less colorful in outward form. This ever-merging of interests is having a marked influence upon architecture, and the visual difference that has made the farm, the village, and the city so entertaining in their contrasts, will gradually disappear.

At present there seems to be no evident stopping of the development of the city. Proportionately each year finds a greater and greater part of the nation's population city-dwellers. All the easy means of transportation, of ready communication, that might be thought to spread population, continue to have the opposite effect and are greatly aiding in its congestion. So that with all the difficulties of living, with all the noise and the dirt, with all the transportation problems, the city gets bigger and doubtfully better. Under any such concerted movement there must be some reason, some definite appeal. The appeal actually is varied. It represents opportunity for wealth, knowledge, art, recreation. It is a social life of many view-points because of intense specialization. It has a larger freedom from responsibility. To it is drawn the educated — for there they contrast their ability; the craftsman — for there is where the greatest skill is necessary; and the trader, who ties the social fabric of specialized effort together.

Aiding in this movement toward urbanization, specialization takes a permanent position. As has been indicated they are definitely related and are almost synonymous, for there has always been specialized effort in towns. The old trade guilds of the Middle Ages come immediately to mind as an example, and because it is an old and tried form of division of work it is held up for emulation. Here of course the craftsman was both designer and manufacturer, and often trader as well. In the specialized effort that grows up within the machine technology these are divided, and it is in that division of labor that harm is generally seen. Taking into consideration, however, some of the older methods of working, we find that the division was almost as great as it is today. For instance: the manufacture of cloth maintains practically the same separations of effort as existed in the Middle Ages, if we leave out the question of design which was then more communal than it was individual, as each trade group had a small amount of knowledge which it passed down from master to apprentice. It is the enormous increase in all knowledge, to be attributed as much to an increase in intellectual curiosity as to an increase in mechanical ability, that naturally leads to specialization. When it is no longer possible for one small group to understand and use the knowledge at hand, there is a natural tendency for the group to split into special units leading to the growth of the expert. And in that category we may place the expert laborer of today who is trained in several days to pass from one mechanical operation to another. It is well known, even granting the deadliness of the work, that it actually requires a higher degree of intelligence than the rough labor of the past. The speed of modern production necessitates the breaking down into the smallest units any form of work. Also the increase in the amount of production calls for larger groups of workmen. These two factors, speed and quantity, are made necessary not so much for the sake of wealth but to keep pace with the demands of an ever-increasing world population, to meet its requirements and maintain it against all the social diseases that existed under the past congestions of population. No one can question that China would be freed from the great famines that devastate it almost yearly if the old agricultural civilization were aided by that of the machine.

Probably the most interesting phase that has come from specialization is organization. Industry, to function at all in any large sense or where mass production is necessary, is absolutely dependent upon management and the ability to organize itself. For instance: in the building industry where up to the present time machinery in actual construction has been used almost exclusively in replacing rough labor or hauling, it is the ability to manage and organize work and materials to meet the crowded working conditions at the site and in the carrying of materials through congested streets, that has brought into the industry those savings that have been effected.

With materials purchased from and manufactured in not only the nation but the world at large, an amazing system has been developed to expedite their arrival at the proper time and prevent delays. And while to a great extent there has been a movement to fabricate at the factory individual parts as units, with a corresponding economy, it is, however, the ability to plan and correlate as to time and place that makes even these units possible. All the different parts of the entire building industry — capital, design, and construction — are so interwoven as to act as one party.

In fact future economy in building must mean an even closer co-operation between the designer, the builder, and the manufacturer, so that it is possible for all three groups to merge and act as one, as they now do separately in many respects. This will enable the industry to establish departments of research and also bring into effect a stabilization of work that is so badly lacking at the present time.

The fact remains that specialization in both physical and mental work has been increased under machine technology, and has been a contributory cause to a change in our way of living.

Specialization has brought a great change in the relation of women to the social structure. Up to the time of the introduction of the machine woman has had a very definite series of occupations. The peasant woman was both farmer and housekeeper. The woman of the craftsman class was mostly housekeeper although she sometimes worked in factories of a type, for it must be remembered that the factory system existed long before the machine. Women in that type of industry were as much robots as can be claimed for men working on an automobile conveyor belt. Her work was largely of a physical kind, without much outlet mentally. Art interests such as sewing and embroidery were in the doing of designs slowly and painfully acquired and belonging to the community, the methods being hand-me-downs from the past. Her work is well described in the old saying — "Woman's work is never done; man's work is with the sun." The work she did with tools, such as weaving, was of a cottage type, something that had to be done when other tasks were finished. Woman had a full working day, for she worked even when the man was playing. Her virtues were chastity and industry, both needed in her relation to society as it existed then. Practically her only outside recreation after marriage was religion, which accounts for the great hold that religion has had on women.

When the machine was first introduced into our civilization her condition was worse, if anything, and in some industries has not improved even today. It is especially interesting to note that this condition exists in the industry that was once almost solely hers — weaving.

Before the late war women began to prepare themselves to go into other industries than those relating to the home, and it was considered by both themselves and their employees a method of cheap labor, a stop-gap on the part of women before marriage, when definitely she took her position as a housekeeper, a position for which she was trained.

We have then, for the first time, the middle-class women working outside the home, enjoying somewhat the liberties that were considered the rights of men. A beginning was also made in studying for the professions which were jealously guarded by the men. During and after the war, however, the necessity for their labor in all fields was evident, and at present the prejudices against them are slowly disappearing and an understanding of equality is gaining. We therefore find in all classes of women, rich and poor alike, a similar interest in industry, with no differentiation of motive, that is usually accredited to the men.

This has led to a greater study of the housekeeping problem, the introduction of labor-saving machinery, and to a specialization, a breaking-up of general housework, and in turn has given the women the greater freedom that they desire and for which they are being trained. Gradually all the cottage industry that women participated in has been absorbed by factories outside the home, so that the housewife no longer makes the clothes for the family, no longer bakes, and is confined at present to fewer of the tasks of drudgery for which economic machines have not as yet been developed. It can be readily foreseen that such an absolute change in the relation to the social community is going to greatly affect our consideration of housing. It means a change in a human need that will be and is reflected in our architecture, not only in the city but in the country as well. It has already become evident in education, for the nursery school, which takes care of children from the age of two years, and the kindergarten are growing very rapidly.

Into the picture of the change in social requirements there is the question of the effect that the shorter working time will have upon our lives and the buildings in which we live. Edison and Ford, both advocates of the machine, are as one in claiming that less time will be required in the future for all classes to achieve the necessities of life. If this is true, and the tendency seems in that direction, there will be more time for recreation, study, and travel. Shorter working days and the shorter working week mean leisure, and with the development of the possibility of having at one's command within the home all the intellectual means of recreation, the home itself may be made the centre of a life intensely interesting. The lessening of the need for physical labor will make it necessary to find other outlets of a physical nature to take care of bodily health. We shall enjoy a more complete appreciation of the physical, because it will be part of play rather than of work, and if Schiller's doctrine that the play impulse is the basis of artistic creation and appreciation is reasonable, a growth in artistic creation and appreciation may be looked for.

II

THE other factors that have changed our conception of our needs are those of transportation and the ease of communication. As it was pointed out heretofore, their tendency has been to increase congestion rather than to dilute population, for while the automobile has made life on the farm more easy, it is the city and its suburbs that have been increased in size because of the ease of getting from one place to another, until the congestion is so great as to offer a continually aggravating problem. In fact it is transportation that causes congestion because you find the village with traffic problems just as aggravated as you do that of the city.

We have gone into these phases of modern life because they have very definitely changed the problem that architecture has to meet. They have indicated the growth of the community way of living, of a co-operation of effort that pertains to all phases of our life. Individuality in the primitive sense has disappeared, and an apparent standardization of the forces that make up building is in evidence. It would seem that the architectural problem of the future is to be one not of designing individual units but in designing communities. One thing is sure, this change in outward form of living, this increasing dependence of one man upon another, will affect our culture and our architecture. The question is — will it mean great hives in which all the requirements of man are met, those of work, of play, of living, or will the lessening of the necessity of physical labor, because of the increase of co-operative effort that must come with the full realization of the machine technology, enable man in rural conditions to live a life such as theretofore has been possible only in the city, or will those conditions which we have associated with the country appertain to the city?

The tendency of the past has been for groups to work together while living in individual houses. This is slowly changing. At present the construction of apartment houses and hotels equals approximately 50 per cent of the total housing built. Into the question of all building must come, besides the use to which it is put, the economic factor of costs to fulfil that use.

Before the introduction of the machine, 90 per cent of building costs went into the shell of the building, and approximately 10 per cent into all other costs. Today, as far as the cost of the individual house is concerned, the cost of the building proper accounts for but only 45 or 60 per cent of the total. It is easy to see that the shell is not the main item of expense; the cost of the use of money, the cost of services such as heating, plumbing, and electrical, together with all the street costs of sidewalks, water and gas mains, and sewage disposal, are to be included in the greater part of the cost. If any saving is to be made it is in the respect of the grouping of services into the tightest congested area so that a lower cost is spread over the greater number. Another cost factor that is to be considered is that of maintenance, in which housing is different from transportation. A great many attempts have been made to devise the mass-production house, factory made and so constructed as to be assembled in as large pieces as can be easily carried by freight or shipped by automobile. While there is no doubt a saving in cost in the manufacture and assemblage, and while also its design could, like the automobile, call to its aid a corps of experts, it is fundamentally wrong in its conception. It is based on the thought that women will still occupy a relation to the house similar to that of the past, and also, as we have just shown, the costs of the site still have to be allocated against the structure. The idea of individual service plants is a wasteful one — calling upon a general expertness in mechanical knowledge that is contrary to the movement toward specialization, whether that movement is healthy or not. The fundamentals of future housing should be, other than those of human occupancy, low initial costs and maintenance and a pooling of the responsibility of service and operation.

Any design that can be perfected in the mass-production house can also be arrived at in another type of mass production which we shall call community housing. The use of bathroom units wholly fabricated at the factory, and other standardized units which are already in evidence, will make for better systems of design than the idea of producing individual houses in mass.

Another point against manufactured housing is that mass production in commodities, such as the automobile, depends upon a rapid depreciation of value and therefore a rapid turnover. The psychology of housing and transportation is entirely different. We have long thought of transportation as a succession of temporary units. It has actually been based on the life of a horse or an ox. We are content therefore to follow the automobile manufacturers with their yearly models. On the other hand, housing ing has always been considered from the view-point of low maintenance costs, it has had a conception of permanence connected with it which tends to make it difficult to sell anything which is designed to have an early obsolescence. Another difficulty in respect to the standardized single family unit is the fact that ground conditions vary to such a great extent. This fact tends to bring into any building operation a degree of error other than those caused by poor engineering. To be added to the score against the mass-production house is the very decided factor that obsolescence of structure markedly affects depreciation in land value. It is readily seen that a district in which many of these houses are placed would rapidly decline in value and in class of occupancy. And while, until the social problem is solved, a large portion of the people can never expect to occupy new housing but must find their housing in used houses, it is evident that such a rapid depreciation will be a determining cause in further exaggerating a condition that always has been an aggravated one. Still another hurdle to be jumped is the question of standardization, for the very nature of mass production in such a commodity would lead to an early fixing of the standards used.[1]

This desire for the mass-production house has come about because since the beginning of this century, to say nothing of earlier experiments, serious attempts have been made to relate architecture to machinery. Frank Lloyd Wright, Le Corbusier of France, Gropius of Germany, and many others, have tried to make the analogy. Enamored by the possibilities of the machine as indicated in the automotive industry, they have endeavored to apply the same principles to a great industry whose products are still largely hand-made and in which hand craftsmanship is still necessary for its success. And to further force the analogy, they have suggested that the external design of architecture should resemble the motor car, aircraft, and the steamship, forgetting that the design factors in these structures (other than those of pleasant appearance, which has greater weight in the automobile than in the others) are due to the functional necessity of their mobility. In this view-point there is a great deal of false modernity, of men trying to grasp the essentials of a social change and not truly comprehending them.

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[1] See *Architectural Record* of January, 1930—"Mass Production and the Modern House," by Lewis Mumford.

The problem that must be faced in housing is the putting aside of the old sentiment in favor of the single house and, in order to obtain economics in building, the adoption of construction in which savings can be obtained by organization and the use of readily improved standard units. The single house has already lost a great deal of its appeal to the sentiment of its occupants. It is no longer a birthplace, and is now but rarely associated with the life of a family. A single house, especially in this country, has but very few ties as compared with the old family home. The tendency is for people to be born in hospitals, to be reared in schools and to live in apartments, and while there always will be privately owned single houses they undoubtedly will be fewer in number.

Taking into consideration specialization of effort and urbanization, together with the fact that women will no longer occupy solely the position of housekeepers — facts inherent in the tendencies produced by the machine, we can easily foresee that housing must be developed to make living easier rather than more difficult. We therefore must look to see the community idea develop in a larger sense. We will find the co-operative idea we have noticed developing in apartment houses within the past twenty years, carried on to a larger extent. The services of light, heat, power, water, and many others will become, because of the need of expert technicians for their maintenance, a community responsibility. Machinery, as a labor-saving device in the home, is in its infancy.

The future use of land, because of the necessity of providing room for open-air recreation in both the country and the city, must be considered with great care. A step in that direction is the village of Radburn, New Jersey, where land is being set aside for parks and other recreational purposes just as the land is laid out for building. The costs of the services, however, still add materially, because of the spread-out nature of the development. The cost of these services per family housed is, in the light of the savings that can be effected, still excessive. The great amount of roadway necessary, the cost of lighting, the cost of the telephone equipment, the cost of the individual heating and cooking units, are all in excess of what they need be if they were pooled. The benefits to be derived are largely still based on the sentiment of "every man's home is his castle." The loss of real privacy, however, because of the close proximity of each house to its neighbor, would seem, together with what each family must pay to enjoy that sentiment, a rather large cost factor.

We will, without question, in the next generation discard the single family house and go in for multiple dwellings in the country as well as in the city, for it is the answer to living in the machine age. In other words the answer is the much debated, much deplored, much applauded skyscraper.

In the old days each man chopped his own fuel, grew his own food, and made his own clothes. Each family was largely an independent unit as far as the necessities of life were concerned. Today it is different and each one of us is dependent on many others for our very existence. Our efforts instead of being scattered are specialized, and we are definitely a part of a very closely knit society. The skyscraper is the method of living in this society; it means mutual dependence and a mutual saving in effort.

While fundamentally the skyscraper is a means of developing land, started as a speculative attempt to increase the land value and the return on money invested, it has grown into a mode of living that fits the new age. It is blamed for congestion of the city whereas it has enabled the city to congest without danger to health. It is in its beginning as a method of building, and, where city planners really comprehend its nature and plan the city for its sake, many of the disadvantages that are blameworthy will disappear.

In other words in discussing skyscrapers we must keep in mind the fundamental reason for their future development, the changes in living conditions they have actually brought about, and from these give the trend they will take. It is not difficult to show them a future necessity, not monstrous, as critics would have them, but as pleasant in their possibilities as was the old urban and village life. The skyscraper is much more than a means of releasing more land, it is much more than a conglomerate structure of steel and concrete with miles of pipe and a system of transportation of its own; it expresses the desire of people to live in communities. The tendency heretofore has been for the city to spread horizontally over immense areas making social intercourse and trade conveniences very difficult except for very limited communities. Skyscrapers permit a closer congestion, a larger sense of unity to the city. In fact they become minor vertical cities within the horizontal major one, and they should be considered from the view-point of a city and not of a building.

It is interesting to note that the congestion which we find in the modern city is but the growth of an age-old idea, and the skyscraper is taking the place of the old narrow streets where in the mediæval towns the different trades worked and lived. More and more the skyscraper is being considered as a vertical community, a community that, were it spread horizontally, would need shops, places for recreation, transportation, work, and places for living.

Unfortunately, the skyscraper has grown up on land that was planned for small buildings and on streets that were planned for horse-drawn transportation, therefore the evils of bad planning and bad use of land have been blamed on the skyscaper. It is an interesting commentary that the coach was introduced into England about 1564, and that nearly seventy years later when there were about twenty-four of them employed as public carriers, a proclamation was issued prohibiting their use "because the common passages were obstructed by them."

It is obvious that the city plan must be considered more flexible, that some means of land allocation must be devised to take into account the changing of standards, for it is certain that future changes in conceptions of city plan will take place. No plan that can be set down can hope to fit conditions fifty years from now. We can only glimpse what may happen, prepare a plan that seems to fit those suppositions and leave land and building development to each generation. Under the present system of economics, which is by no means a satisfactory one, we find that convenience gradually works within the conditions as they exist.

There can be no question that ideas develop much more rapidly than can be properly arranged for on any fixed plan. What a new means of transportation such as the airplane may mean eventually to the city plan is impossible to say. What we can be assured of, however, is that it will mean a change in conception just as the stage-coach changed twelve-foot streets to wider ones and just as the automobile has made them still wider — the latter change coming within some twenty years. There are, moreover, some fundamentals that must be observed in the development of the future city, especially in view of the increased size of building units.

That buildings are going to cover larger and larger areas, not only in the city but in the country, is evident. We shall find them planned for populations as large as we now consider sufficient for a second-class city. These enormous buildings will be planned to house all the requirements of life, with places devoted to work, apartments for the several levels of income, theatres, auditoriums for music, schools, garages for automobiles, hangars for airplanes, and all the shops necessary to feed and clothe such a population. These buildings, without doubt, will be owned and maintained on a co-operative plan.

As we have indicated, we have been endeavoring to fit the vertical city to the horizontal plan that has existed for thousands of years. In the old horizontal plan until about 1800, even in the largest of the old cities, it was possible to walk easily from one end to the other. Since then it has been necessary, because of the urban tendency, to develop means of transportation until we find problems of congestion in cities such as London and Paris, where the skyscraper, except in very rare cases, does not exist.

It would seem that the idea of transporting millions of working people daily between their work and their place of living has about reached its climax. It would be much more reasonable if the working population could be maintained much closer to its work and an effect similar to the old cities maintained in principle.

This can be done fundamentally if a plan is designed to scatter business in such a way as to leave places for residences adjacent;

either by adopting Le Corbusier's plan for the skyscraper city, or by housing the working people in the business building itself.

The solution of the transportation problem is not necessarily a matter of double-deck streets or more streets, but rather of less. The plan of the skyscraper city could easily be one of fewer but much wider thoroughfares. One of the great difficulties in our present street system is what to do with the stationary vehicles, either those that are parked empty or those parked for taking or leaving freight. Four-line traffic streets are cut down to practically one lane. The service of the many is therefore interrupted by the necessities of the few. It is a fundamental that in a proper city plan streets must be made to serve their proper purpose, that of motion, and parked vehicles of every kind must be removed and placed where they belong, and that is on the property of the person interested.

The plan should be made so that vehicles designed to go at forty miles an hour or even at a greater speed, may go at that speed without interference. The streets should be so laned that local traffic will not interfere with express traffic. Another thing these enormous buildings will do, if planned as indicated, is take care of all phases of living and remove from the streets a great deal of pedestrian travel.

Without going into the question of artificial light and ventilation, because it is not necessary, it is possible to design buildings economically for housing activities, which will take care of a free use of natural sunlight and air, giving greater privacy to the individual and relieving him from all responsibility of mechanical maintenance.

The possibility also of devoting the larger part of the ground floor to the reception of automotive traffic and of the necessary freight, will enable a freer use of the streets. In a building such as is here indicated it will not be necessary to consider the use of the ground floor for shops. They can, because of the large population housed within the building, be placed at a more central point and will probably be of a co-operative nature. Another possibility is the use of the first few floors above the ground for the parking and garaging of automobiles. This is already in evidence in

American commercial buildings where ramps and automatic elevators take care of a large storage problem without loss of time, and there is every reason to believe that both the noise and the noxious gases in the use of the automobile will soon be eliminated, thereby freeing the city from a great deal of its present annoyances.

Taking into consideration the increased amount of appreciation of leisure (which is accompanied by a desire for outdoor recreation), these centres of living will probably be placed on rapid-transit lines reaching out to landing fields of the airplane transportation, which will, owing to the increased size of the individual plane, take care of a large transitory population. Paralleling these transit lines will be the express highways for fast-moving automobiles which will take even larger groups of the population to nearer points.

The city itself, however, must provide for large open areas for recreation in its own bounds. There is at the present time no city devoid of land of low value within its limits that could be used for just such purposes. The example of Chicago and the counties immediately adjacent to New York show that with a definite social plan a great deal can be accomplished with relatively small cost. There can be no question, for instance, that Westchester County, close to New York as it is, will lose, within the next fifty years, its rural character. The forethought shown in the provision for the great parkways and the recreation centres will prove of great benefit then as well as now, as the multiple dwelling is beginning to follow these parkways.

It may seem absurd to show any such picture of future living conditions, but no matter how great the strides in increasing the production of food products, no matter how great the strides in transportation, communication, and power transmission, some conservation of the use of land is necessary. The type of community life that is here indicated will, without doubt, use the land to better advantage than is possible under a thin spreading of the population.

This is a time of rapid evolution, so rapid in fact that looking backward but ten years we gain the impression of a revolution, and if the changes in mode of living are as revolutionary in the next quarter century as they have been in the past, no one can say what the outward aspect of our civilization will be. Of this we can be sure: that it will change and many absurdities of today will be living conditions of tomorrow; that criticism will be just as strong as it is today, and Utopias still will be the dreams of the critic and the philosopher. And the new ideas will be contrasted with the past (that is, today) with the idea that the latter should be emulated.

CINEMA
GUILD

XII — WORK AND LEISURE

By LILLIAN M. GILBRETH

I

AN ENGINEER is a person who believes in measurement, who knows how to measure, does measure, and is willing to abide by the results of this measurement, whether they suit his preconceived notions or not. It is necessary to state this at the outset of this discussion, because it explains his whole attitude toward work and leisure, and it is from this attitude that I approach the subject of this chapter. The engineer realizes distinctly that we have not yet found units, methods, and devices by which to measure intangibles as well as tangibles. This does not discourage him in trying to find such units, methods, and devices. He feels that by advocating and practising measurement he is not confining his field of interest to those things which can be measured, but simply that he is pledging himself to apply measurement to the things which can be measured, as far and as fast as he can, and at the same time to look for ways of measuring things which as yet do not submit themselves to any type of measurement that he knows.

This means that he is constitutionally and by training willing to submit his own activities to measurement, and that his answer to those who "indict" him as hampering mankind's advance toward civilization is "Let us measure."

This is no theoretical definition of an engineer and of the engineer's attitude. It is taken from no dictionary. It is derived from a study of the engineer's code of ethics, from a review of his training, from a first-hand knowledge not only of what he does but of what he thinks and feels. It expresses in his own words his notion of his duties and responsibilities. It should serve as an indication that he is a thinker as well as a doer; that within his own field he knows what he is doing and why; where he is going and why; and that he is willing to explain what he does, to accept criticism, and to co-operate.

Because of his training and his methods of thinking, he is perhaps a bit overprone to definition. He wants his problems stated clearly and in detail. In considering work and leisure, for example, he must know exactly what is meant by "work" and by "leisure." Yet in spite of this demand on his part, he sees that work and leisure should not be considered separately but as components of a total situation. He lives with people — in industry, in business, and in the home — through the whole scope of their twenty-four-hour day. The way in which these men and women act and think and feel — come within the scope of the indictment made against this machine age, for which he is held largely responsible.

The engineer feels that they must be studied through the sweep of all their activities, if we are to understand what work and leisure mean to them. One cannot understand the man at the bench, the woman at the machine, without knowing the home situation and what is done during the hours away from work. The teacher, the housewife, the girl in the office — all must be thought of on the job and off the job, to get a fair picture. The problem ramifies out extensively into every phase of life.

In order to start the discussion, the engineer uses the definitions of work and leisure which seem to be acceptable to those who are indicting him. This means that "work" covers the time a man is obliged to expend energy productively, and that "leisure" covers the time he is not obliged to "work." The implication is that work offers an opportunity of expending labor in a useful or remunerative activity, and that leisure offers an opportunity for freedom from work, or ease or relaxation. These definitions seem to take it for granted that work and leisure not only can be but should be separated, both in our thinking and action — a questionable conception. Why not rather consider people as having certain wants or desires or urges, and as seeking certain satisfactions? We all want to create and express our personalities. This fundamental urge leads us to want other things — activity at some times, inactivity at others; society at some times, solitude at others, etc. This profoundly affects both work and leisure. It is important that one have the things that satisfy. It is not so important whether one gets these things during the work period or the leisure period. The engineer asks that the problem as stated include data on these points.

He asks, also, that work and leisure be considered from *within* as well as *without*. He is glad to listen to the comments of those who look on industry and business and their effect on home life and the other activities of the twenty-four-hour day, from without. He is willing to acknowledge that his own life within industry may keep him so close to details that he fails to see certain big things outside his immediate field of vision. But he does claim that this very intimacy with details, this first-hand inside information as to what the worker is doing and thinking and feeling, gives him certain advantages. He is constantly, though often unconsciously, measuring these acts and thoughts and feelings among which he lives, and can submit data as against opinion.

His next request is that all preconceived notions be laid aside, or at least submitted to a new survey and a re-evaluation. "Work is a hardship," "leisure is a pleasure," "work is a pleasure," "leisure is a hardship," — may or may not be false. He recognizes that there is good authority for each, in the experience of the past. He asks only, "What is the case today?" "Should one make any such sweeping statement?" "Are there not different kinds of work and different kinds of workers; different kinds of leisure and different kinds of leisured?"

He asks even more questions. Have work and leisure opposite urges? Does the man who spends his time at work prefer to spend his free time at something entirely different? If he runs a machine at his work does he long to get away from running any machine in his leisure, or does his pleasure in operating a lathe or a drill press give him an added craving for operating an automobile? A question not easily answered, since the shop operation means staying indoors, while operating an automobile means being outdoors in more interesting surroundings.

Are work and leisure mutually exclusive, and do we like them to be so? Are we separating work more and more distinctly from rest periods, and does this give us more, or less, satisfaction? Or is there increasingly a fusion of the two which makes it difficult to state when one is at work and when one is at leisure? Are work and leisure of the same category? Can we measure and compare them in terms of activity or of freedom or of satisfaction? Are they of equal importance?

II

THESE questions are not easy to answer, and the engineer is perhaps not sure that his answers are satisfactory even to himself. He feels that they are not so much opposites as complementaries; that the two together, in varying proportions, make up a satisfying life; that they are not mutually exclusive, but that there is increasingly a fusion; that they are of the same category but not of equal importance, work being by far the more desirable.

True, the engineer may be prejudiced, because he finds work so absorbing and satisfying that he is prone to use leisure as a rest period during which he can "clean up" and "get ready" for the next job. His critics probably will exclaim here, "This is exactly what we expected and is an indictment against the machine age." Is it not possible that some of the critics may be wrong and that satisfaction may be an indication neither of decadence, nor of lack of understanding, nor of mechanization?

Is work a fundamental need? The worker says "yes." If he has ever personally faced the serious problem of unemployment, and its effect on his physical and emotional satisfactions, then problems concerning the relationship between work and leisure *in* employment seem of little importance. The engineer wonders how many of his critics have faced problems of unemployment, personally or as active participants. The man in the shop, the woman in the office, the housewife in the home, the teacher, any and every member of the industrial community out of a job, not wanted, not allowed to continue to be a producer — what would they say? Are we wrong in having developed a race of men and women who want to produce, to contribute, to have a job? The engineer thinks not. Finding, as he does, the greatest satisfaction in having a job, he feels he should share this satisfaction. Has he perhaps helped develop a race who lose themselves in their work and find it hard to adjust when interrupted by accident, illness, or loss of employment? This is possible. If the responsibility is his, he must do his share to find methods of better adjustment.

Is leisure a fundamental need? Yes. Finding in his own work such complete satisfaction the engineer has perhaps sometimes failed to realize that all jobs are not like his, and that they must be supplemented by more leisure, differently spent. More time free from work, more background and education with which to enjoy leisure, more opportunities to get in it those things which one has been taught to want. Perhaps he needs more and better-spent leisure too.

Someone asks here, "Has the average life a conscientious purpose?" Perhaps not — but is this the fault of the engineer? His own life usually has. His own technique makes the first question he asks always, "What do we want to do?" Perhaps he assumes that everyone thinks as he does. How much opportunity has he really had to motivate the life of the average person? He can and does serve as an example of a life with a purpose, using "example" not as a "model" but as an "illustration." Is not "purpose" closely related to "creative urge"? This we must discuss later.

It might not be out of place here to spend a few moments discussing "work" as the engineer considers it. It may be roughly classified into —

1. Handling materials
2. Handling machines
3. Handling money
4. Handling forms
5. Handling men

What is the effect of each one of these on the worker as he turns to his leisure? Actual handling of materials, fabricating, transporting, etc., is done increasingly by machines, but the number of materials one can know increases constantly. Knowledge of these materials increases constantly. Opportunities for inventing, for inspecting, for testing and comparing increase constantly. As a result we are thinking in new materials and in new uses for materials. Machines, machine tools, hand tools, and everything that they make is affected by this. The airplane, the automobile, the refrigerator, the typewriter, food, clothing — everything is affected. Limits are expanding. We do think and feel things differently than ever before because of the changes in materials, and this affects our leisure as well as our work.

What about handling machines? We must concede that the older type of machine was thought of primarily as an aid to production. It "took the place of a man." It was the competitor of man. A man "tended" it; he was a "hand," and his hand started it, repaired it, and stopped it. To an outside observer quite naturally he seemed its servant, or even slave. It was often so designed that he was uncomfortable, physically and perhaps mentally, while operating it, and much fatigued after operating it. If it created noise and dirt, if it brought with it problems of temperature and humidity and ventilation, if it housed its attendant workers in shop and home inadequately, this was looked upon too often as a matter of course.

But our whole conception of machines has changed. The progressive engineer today thinks of a machine not as a substitute for a man, but as an extension of a man. This affects machine design operation, housing, and every other phase of the handling of machines, and influences both work and leisure.

Handling money — once considered only a problem of finance — is now recognized as a factor of many types of activity. The technique of handling the actual money itself has developed, so that it has become the subject of motion study and other types of job analyses. We are thinking through time and space and activity in terms of money and money in terms of these, so that we have a much more stimulating activity. The same thing is true of handling papers or forms. These have in many ways "come alive." A technique has been developed, which covers not only effective work methods but specifications for those doing the work and satisfactions to be expected.

As for handling men, it must be conceded that this was the last phase of work activity to be adequately considered. But the emphasis has swung increasingly to this phase, until now we have perhaps too much time spent considering the human element, forgetting that unless our materials, machines, money, and forms are adequately handled, our men have not the greatest opportunities for development. What does all this mean to work and to leisure? It means the possibility of the individual being much more effective, as well as society as a whole profiting not only by production but by the satisfactions that come from being effective. It means a cyclisity of invention, design, manufacture, and use, developing as a spiral.

Perhaps no one seriously doubts this last, though many still question the effects of handling machines. This leads us to ask, "What is the relation of labor-saving machinery to work and leisure?" "Does it necessarily decrease the first and increase the latter?" The economist, where he has had a chance to make himself heard, has demonstrated that in the long run machinery and increased production means more work, in the sense of more employment and higher wages. This does not prevent periods of lack of employment and of unadjustment. It is a question whether it is a problem primarily for industry or the engineer to handle these interim periods of unemployment. It is unquestionably a problem of society as a whole, of which industry and the engineer are members. And it is a problem being successfully solved where society as a whole, functioning through its competent members, is going at the job intelligently.

III

THERE seems no doubt that labor-saving machinery is reducing the time which it is necessary that men must work in order that society have enough not only to exist but to enjoy existence. Whether this will result in fewer people having to work, or in work ceasing at an earlier age, or in fewer work-days in the week, or fewer work-hours in the day, is yet to be decided. It should depend largely on what the worker himself wants. No one can say what he *will* want. What he *does* want now is an assurance of a job for as many of his group as possible; the maximum of work-years; but the minimum of work-days and of work-hours on those days.

This leads us to ask, "What is the first-hand opinion of workers of 'this machine age' about machine operation, and especially work at machines? Do they regard it as slavery, or extension of personality or self-expression?" Those who indict this machine age take it for granted that the average worker dislikes work. Now a worker is no different from any other person. Human beings, even animals, feel urges for activity and urges to cease activity. The worker has these urges like everyone else. We all at times feel that it is irksome to be obliged to work, at times feel that it is a relief to be obliged to work; that there is a certain amount of stability and permanence and a feeling-of-being-needed that is attractive. If the obligation matches the opportunity, if the time when we *must* start and stop fits in with the time we *prefer* to start and stop, we are lucky. The return for our work is important. The conditions under which we do it are important — the people with whom we work, and all the other factors of the situation. Of course it is natural to associate anything unpleasant connected with work very closely with it, and even to blame the work itself for things traceable to other causes. The average worker is not a philosopher, does not reason logically, and is apt to say that he "hates" work or is "a slave to his job," when really he dislikes something connected with it. We may therefore discount a large number of the complaints we hear as unimportant. Then there are always people who exaggerate and dramatize, or look upon themselves as abused, or fail to adjust for one reason or another. Against the opinions of this group we place those of the people who consciously feel satisfaction in work, who regard it as an opportunity for self-expression, and who believe that they are masters of their work and extend their personalities through it. These people are often inarticulate, but we who spend our lives out in industry, watching men and women at their work and running their machines, know that the number who get satisfaction in their work is large and increasing. This is partly because working conditions are better; so are wages; so are the people with whom one works. It is partly because machines are designed to relieve the worker of drudgery but not of the joy of creation. They are easier to operate; they cause less fatigue. Only one who has operated the modern machine and has watched machine operators and studied their motions and their emotions can testify intelligently here.

Do workers feel that their work makes them more, or less, capable of enjoying leisure? That depends. Certain high-strung individuals at both mental and physical work, are irked by it and the conditions under which it is done. Noise, heat, grime, speed — these wear on certain types. There is a possibility that their number may be increasing, also that one does not get sufficient data in the shops.

It is true that some workers feel that they are too tired when they leave work to enjoy leisure thoroughly, but it is difficult to find out whether or not this is due to the high pressure under which life is lived today, which traces back to the many causes for which the engineer is not to blame. It might be due to dissatisfaction with life or with oneself; to being at an unsuitable type of work; or lack of training as to the best, most interesting method of doing the work; or because leisure is not attractively set up.

Again, a worker with excess physical or mental capability may fling himself into his leisure and demand of it more than it can give, blaming the work itself rather than the leisure. It is the job of the engineer to know leisure as well as work opportunities, to do what he can to make the leisure what it should be; then to set up the work in such a way that work plus leisure shall be most satisfying. For example, if he knows that the only leisure his workers can get is at motion-picture shows, running their automobiles through crowded city streets, and other nerve-racking amusements, it is his job to provide for adequate, quiet rest periods within the plant. If he knows there are opportunities for real relaxation during leisure but few opportunities for physical, mental, and emotional outlets, it is his job to see that the work and the rest periods within the plant furnish the necessary stimuli. As yet only the rare engineer or personnel man recognizes this, but the theory is being increasingly accepted and in due course the practice will surely follow.

As for the effect of leisure upon work, a certain school of thinkers feel that leisure today offers a real "threat"; that we are not training our people to enjoy leisure; that what they find in their hours away from work sends them back to work exhausted and dissatisfied. This is difficult to prove or disprove. Is it fair to say that the technician has furnished the machines which make possible a leisure too exhausting? He can scarcely be blamed for a misuse of his machine, any more than he can be praised for its proper use. He is increasingly providing more leisure and accessories toward making it interesting and amusing. Nor must it be forgotten that he is busy at work on rest devices, like chairs and beds. He is putting comfort as well as efficiency into automobiles, street-cars, buses, trains, and other means of transportation. He is introducing the principles of least waste of motion, and consequent least fatigue, into restaurant, place of amusement, and home, as well as shop and office. He is eliminating smoke, noise, and unnecessary eye-fatigue outside as well as inside industry.

It may well, perhaps, be asked, "What is all this leisure for?" "Are we sending our people back to work from their leisure periods really rested and re-created?" The engineer must face this problem not only as an engineer but as a member of the social community. He may meet his responsibility as engineer better than he does that as member of the social community, but the latter he shares with every member of the community, engineer or not.

Fundamental to a right use of leisure is a right philosophy of life, which makes everything and everyone interesting; which enables one to detach himself from his own peculiar situation and enjoy people and things without jealousy or covetousness; which teaches one what to remember and what to forget. Along with this come certain necessary habits — ability to take leisure whenever and wherever it comes and to enjoy the opportunities it offers; ability to relax quickly and easily and to be back on the job instantaneously. Here again the engineer may contribute by his practice of measurement: observing, recording and tracing back to causes, and forward to results.

Naturally, workers do not think through consciously and carefully the effect of their leisure on their work; but one fails to find many examples of workers — or of those who deal with them — who feel that leisure as it is related to work is specially unsatisfying. Certainly no craving exists for a more rigidly controlled leisure. What the worker wants is more free time, all his own, that he may use as he pleases.

There is great diversity of opinion among people at work, as to whether their work or their leisure gives them more satisfaction. Those keenly interested in their jobs, getting fundamental satisfactions as well as adequate returns in money, hours, working conditions, etc., on the whole find greater satisfaction in work than in leisure, especially if that part of their twenty-four-hour day not spent at work is unsatisfactorily set up. The rare few who find equal satisfaction in work and leisure, have probably developed the philosophy and habits before referred to. The group who find greater satisfaction in leisure than in work, do so either because work is poorly set up or because leisure time is used with exceptional satisfaction. Age is a factor. An older person, unless exceptionally happy away from work, with well-established avocations, is more apt to prefer work to leisure. If his family life has been changed by deaths or marriages, he often finds his work habits his greatest consolation, and his working comrades his truest friends. In many cases his physical and emotional demands are rather for rest than activity, and the repetitive nature of his work assures this. A younger person naturally has interests which tie in very closely with leisure.

It is fundamental to this discussion that one considers skill and its relation to work and leisure. The best definition available for skill seems to be that it is knowledge plus dexterity, plus an ability to learn. This implies that the knowledge and the dexterity are subject to improvement; hence can meet different and even new demands. There has been much talking and writing by the intelligentsia, for the intelligentsia, attempting to prove that this machine age is gradually doing away with need for skills. The engineer is so accustomed to hearing himself indicted as failing to teach skills, failing to use skilled workers, gradually diminishing demands for skills, that he has almost come to believe that this is true! How many of these writers and speakers have actually spent any amount of time in industry with workers on and off the job? Or have ever themselves been workers, and long enough to feel and think as workers do, to speak their language and understand their psychology?

The worker on the job does not feel that he is less skilled than his father or grandfather, although he may be more highly specialized. He does not feel, if he operates a machine properly designed and run, that he is showing less skill than if he operates a hand tool. The engineer backs him up in his feeling that he may still be "skilled" in the best sense of the word, if he so desires.

If we accept the definition of skill before stated, certain things are evident. Skill is inherent in men, not in jobs. We may have skilled workers, not skilled work, though it is true that certain types of work offer greater opportunities for the exercise of skill than do other types. It is possible to develop skill on most kinds of work, if one acquires knowledge plus dexterity, keeps on learning, and uses what he learns to meet changing needs. It is a splendid achievement of the Scientific Management group that this fact was discovered and demonstrated.

This means that skill may be transferred from man to man, but not from man to machine. The machine may embody the knowledge; it may take over a large part of the dexterity; it can never, in and of itself, improve or meet changing situations. If we have not often as yet designed machines properly, and helped those who operate them to become skilled and increasingly skilled, that is poor technique — but it is not an indictment of the machine age in its fundamental conceptions.

It should perhaps be conceded explicitly as well as implicitly that the engineer has been learning, by the trial-and-error method, that many machines are still in use which demand little skill to operate, that we have been slow to teach our workers that it is possible to develop skill on almost any work. This is the more necessary as we develop more machines, and hand over to these more and more "unskilled" work. This involves the serious economic problem of providing work for those "released," and the social problem of balancing up change of work with change of leisure. The engineer will always face these problems as a member of the social community, and be expected to contribute time and effort because of his training in measurement. But to him will always remain the privilege of asking, "In how far did I cause the problem that exists, and in how far am I responsible for the solution ?"

As regards the relation of skill to leisure, it may be true that this age does not require so many hand skills as formerly, but it does call for more machine skills. There is among many mental and manual workers, an increasing voluntary revival of hand skills like wood carving and weaving. This is partly to be credited to teaching the children in the grade and vocational schools and to the progressive theories of education back of this teaching, partly to better housing, more attractive home furnishings and equipment, better salesmanship and advertising, more money with which to buy the wherewithal to develop skills, and a keener interest in them aroused through books and magazines. Along with this comes the cooperative work of physicians, psychiatrists, directors of physical education, educators, and others, to arouse us to the benefits of skills. This is more a trend, perhaps even only a tendency, than an existing condition, but one sees indications of it everywhere.

The most optimistic engineer is of course troubled by certain current uses of leisure — speeding, gambling, drinking, interest in crime movies and stories. He is often blamed for these as for everything else wrong with modern life. Yet how many of these are really the result of the changes which his technique has made ? Most of them would seem to rest on a lack of respect for law added to a terrific urge of activity. Climate, environment, inheritance, traditions — all of these things are causes of our strenuosity, our highly charged personalities and our disregard for law. Even the most kindly European critic or native-born critic who takes pride in his European attitude is apt to feel that we should be ashamed of and not proud of our "mania" for size, speeding, heaping up buildings and money and material possessions. But they go a bit far when they make inseparable with this urge a disregard for the small, delicate, and beautiful. They indulge in the same exaggeration for which we are blamed, when they look at the surface indications as all important and disregard the less apparent things which lie beneath. Are we "crass materialists" as a people? As engineers? It takes a rare and understanding student of human nature, like the late Mr. Dana, the much lamented librarian of the Newark Library, or Ossip Gabrilowitsch, to know and appreciate the poet and idealist in the "captain of industry" or the "industrial magnate." It is, however, easy for anyone to see that the engineer has been directly responsible for the creation of beautiful products of his machine and for increasing opportunities for the leisure that educates and enriches. There are more beautiful things to be bought than ever before, there are more people with money and taste to buy them.

IV

We have said nothing as yet as to the relationship of training to effective work and leisure. If the use of our time is poorly organized, then training which results in this, is a poor thing, and we should be blamed rather than praised for it. In some of our higher institutions of learning there is the feeling that the technologists are wrong and that leisure, not work, is the real aim of life. It is certainly true that some people do great creative work in their leisure time and achieve masterpieces which challenge comparison. The genius, the creator, the man who has made something great and fine has a right to admiration, not only for what he has done, but for the way in which he has made the doing possible. But this is no assurance that decreasing work and increasing leisure would enable ordinary men to achieve works of genius.

It has been assumed too often that the man who is busy at an every-day job and engrossed in his work has no love for beautiful things and no aspirations to create them. As a matter of fact the man at the job often perceives beauties in it that nobody else sees. This may be true of a very humble job while another which will seem to the onlooker much more interesting and inspiring may leave its doer quite unstirred. We are finding more and more that the fundamental differences are not in the jobs themselves, but in the people who do them.

Training can only be effective when we realize that work and leisure mean little unless related to the person who is using them. It is no new thought that education must come from within, and not from without, yet we are not always careful in our training for work and leisure to realize that the important thing is that a man expresses himself in both. If we have taught him to know what activities and emotions he must release to get real satisfaction and have shown him how he can effect this release, then we have done a good job in training. As yet not all of our schools and colleges do this; therefore, it is not surprising that we turn out people who rate one type of work above another type, rather than rating a more effective way of doing the work above a less effective; or people who rate leisure above work without taking pains to find out whether the result of the leisure is really worth more than the result of the work.

Again, we train in some of our schools, lower and higher, people who have fine ideals but little conscious purpose in life. They are not sure what they want; hence have little incentive to train for any specific job or to work at what they get effectively. Such people stop learning very young, and furnish us with some of our most difficult but least understood problems. They like the repetitive work they should find tiresome. They have no desire for promotion and rather resent it if it is forced upon them. The engineer is not much disturbed by the problems of monotony, and lack of promotion which the uninformed writer on industrial conditions expounds at great length. He finds little monotony and dissatisfaction with work, and knows that he can handle such problems easily by better selection and placement and rotation of jobs. He is disturbed by the many who are satisfied with so little. He expects to be blamed for these as well as for all others; but he asks of society, and especially of the educators, "Have you done your best to train and send to us to use, men and women who want to learn, who know how to learn, and who are capable of taking the opportunities we can offer ?" It is easy to pass over blame of any sort to the college, the school, and the home, but they must each take their share of responsibility if we are to have the best type of person to make the most of what this age offers. We need people who as infants, children, and adults, on through old age, want to learn, are capable of development, are acquiring constantly an equilibrium which is physical, mental, and emotional, and consequently can adjust to changes and handle work and leisure problems with increasing capability.

V

Certain desirable changes are unquestionably taking place as regards work and leisure. More and more people are working hard and for money — because they want to, not because they have to. These people are receiving increasing satisfactions. This is true all over the world. An increasing percentage of women as well as men, privileged and overprivileged, as well as underprivileged, want economic independence, want to rank as producers, want to earn as well as to spend. This economic independence, rating as a producer, etc., is causing satisfaction, whether the type of work and the type of leisure which come with it are satisfying or not. There is great diversity of opinion as to what this is doing to many of our institutions, and especially to the home. The home is changing, as everything else is changing, but it can never disappear; it must balance up with what the rest of life offers in work and leisure for everyone belonging to it; it must stand for permanence and security and equilibrium; and it will.

Just as more people are exercising work privileges, so more people are exercising leisure privileges, because they want to. Travelling, music, art, reading — one need scarcely argue the spread of these or the satisfaction which they are causing. This all means less sharp demarcation between the various "classes" of our community. It probably is true, as our indicators say, that we all get more or less the same education, speak the same language, wear the same clothes, and even develop the same attitudes. What harm? Our indictors forget that this indicates that a large number are on the way up, not on the way down! that increasingly more and more of our people feel like the people they want to be like, not *different* from them. It is all very well for an onlooker to appreciate highly differentiated types, revel in contrasts and picturesqueness. What of the satisfactions of the people who are different? What of the feeling of the man or woman who knows, after many generations of being different because he had to, that now he can be "like" because he wants to?

It is not true that everyone in our community is like everyone else. We have wealthy people, artistic people, individualistic people, non-conformists who like to look and act and think and feel different from anyone else — and they do just that. The rest of us prefer the comfortable feeling of group solidarity. You get one impression if you look at us trooping down our busy streets or at our work or our community leisure. You get quite another when you see us in our homes and at our individual work and play places. We want to be able to reach the standard; we like to be able to vary from that. We feel that a standard is something which belongs to all of us, and which we can improve slowly but surely to the benefit of us all, but we feel — most of us — that we are its master and not — its slave.

This is essentially a feeling that the difference between work and leisure is largely a matter of attitude, and that the desirability of work and leisure as they are at present set up, is also largely a matter of attitude. If one feels that the important thing is an opportunity to express oneself, to be active physically, mentally, and emotionally, then one's chief demand from work and leisure is opportunity. The length of time one spends at each, the proportion of the thing one wants furnished by each, is interesting; is significant; is not so important as that the sum of the two shall be satisfying. Our critics would perhaps say that this very attitude has changed profoundly — and perhaps unfavorably — our morals and our religion. Is this true? Our individualism undoubtedly does affect our regard for law of man or of God, and the engineer must co-operate with all citizens of this age in law enforcement. It is his place to participate in measuring the rightness and effectiveness of existing law, and in suggesting desirable changes. His experience, however, should lead him to realize what without maintenance, progress which is sure and continuous is impossible. He insists upon this in his plant. He should insist upon it also in his community, in his nation, internationally.

In so far as morals are associated with loyalty, with consistency, with an adherence to principles, he finds much to encourage him in his own field. There does exist, as in the past, loyalty to work standards, real love of materials, of machines, of work methods, of finished product. We find that still the worker will put his hand between two stones coming to rest, in order that the hand, not the beautiful finish of the stones, shall receive any possible damage, because "I can grow a new skin but the stone cannot." The user of the machine, like the user of the tool and the user of the hands without the tool, has ideals of craftsmanship, takes pride in the thing he makes and the way he makes it, and cherishes the opportunity to put his distinguishing mark on his product. There is loyalty to employers and to fellow-workers, as well as to friendships and to families. There is loyalty to the desire to express the creative urge in the shop as well as the studio, in the home as well as the office.

This loyalty carries over into leisure. Our ideals of sportsmanship have not degenerated — all criticism to the contrary. And there is even transference of ideals, for we find the athletic contest in industry, and the ideals of "form" and "skill" which developed in industry, in the sports.

Moreover, "service," which the critics deride as synonmous with profitable business and indict as lacking sacrifice and real motivation, does not on close first-hand inspection prove itself unworthy. There are always people who use a fine thing as a cloak for something worthless or worse, but no one can possibly live in business and in industry without knowing that from the chief executive to the youngest clerk or apprentice, running all the way through finance, production, and selling and distribution, there is a real ideal of service which may not always go through into practice but which guides and checks and redirects.

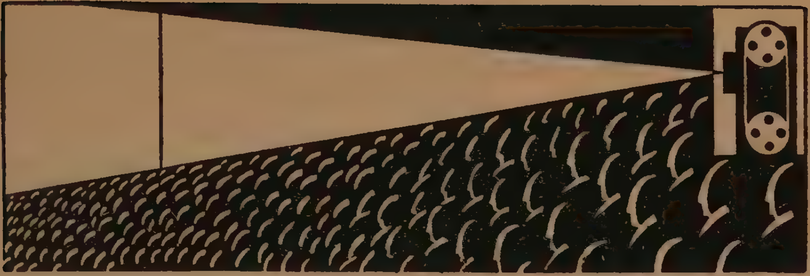
What of the relation of changes in work and leisure to religion? The worker is more, rather than less, of a scientist; more, rather than less, of an artist — potentially if not actually. Certainly more science and more art are coming into the field in which he works and in which he spends his leisure time. Religion is so often confused with display of religious feeling, or with church-going, or with some open and conventional manifestation. Our leaders look up as well as ahead. They have a sense of proportion; they hope rather than despair; they seem to walk surely as well as quickly. That would seem to indicate religion, and as the leaders are, so to some extent at least are all the rest. Naturally we make our images of the current things. So we may seem to deify the things we make and love, but that has been true of all times. The proof of religion would seem to be far more in what we feel and do than in what we say.

It is perhaps only natural, though not advisable, to meet an indictment with a defence attitude; to cite what one hopes to do sometimes, as if it were what one always does do; to minimize the undesirable and overemphasize the desirable; to point to upward trends; to love one's work and the age which gives it to us, so dearly that one "beareth all things, believeth all things, hopeth all things, endureth all things." Perhaps the engineer must plead guilty of this. But is it not encouraging that he does believe that this is a splendid age, that we are moving toward civilization; and is it not encouraging also that he is willing and glad to take his part in making this age what he believes it can be ? He is advocating and practising accurate measurement. He is developing the "science of work." He is co-operating with psychologists and other investigators in the field of the human element in studying the total situation. He is maintaining high ideals in his code of ethics — in his emphasis on service. He is making it possible to transform more types of work into work requiring skill. He is eliminating waste, including unnecessary fatigue. He is advocating training for work and for leisure. He is not forgetting the intangibles. And finally and most important, he is willing to submit himself and his work to measurement, to criticism, and to improvement.

In return he asks for constructive criticism. He asks that his work be supplemented by those who are experts in religion, in morals, in art, in other lines. But he feels he has a right to ask that these, as well as he, shall get their facts from within as well as without, shall weigh and weight them, shall draw conclusions slowly and fairly. If this is done he feels that we may proceed with calmness and assurance toward civilization, knowing that we shall be increasingly adequately prepared.

The engineer is conscious that he is living in an age of great changes. He realizes that he has been instrumental in causing many of these and that his responsibility is, therefore, a vital one. If he has been instrumental in doing away with anything that is fine and for the advancement of mankind, he must see that this is brought back, or that something equally good or better takes its place. If he has brought about anything that is good and fine, he must see that provision is made for its maintenance and he must never be satisfied that things remain as they are, but try always to make the good still better. This he knows. He is quite willing to grant that the machine, improperly designed and used, may do away with the individuality of the product, as well as of the person making the product, that it may result in bondage rather than in release. His point is that it need not result in anything detrimental, that it can be, and that it is being, a blessing to mankind. He feels that, through thought as an extension of personality, the machine frees the worker from drudgery and releases his energy in work that satisfies. More than this he feels that the change in the machine and in the work that it does is coming, not because of criticism from without, but because of a real need and urge from within. It is the engineer, not his critics, who are transforming the machine and the work that it does.

Life, activity is a unified thing. Work and leisure are inseparable parts of it. Civilization results when we use both to develop skills and secure satisfaction. This thought is spreading all over the world. Throughout European industry we find the feeling that any work properly done may be made an instrument of culture. Philosophers, economists, engineers, industrial leaders, men of different countries, experiences, and schools of thinking, agree that work and leisure must be thought of, not as two problems, but as one. At the recent World Engineering Congress in Japan this feeling was expressed again and again and concurred in by Orientals and Occidentals alike. This means that there is no fundamental difference of opinion between the engineer and his critic — both desire for every man a full and free expression of all that he has to express. Whether this expression is the result of work or of leisure makes little difference, so long as it conserves and develops the skills and brings returns in the satisfactions which makes civilization worth while.



XIII — EDUCATION AND THE NEW AGE

By William E. Wickenden

A CONFUSED mass of ruins, when viewed from the air, may disclose to the archæologist the ground plan of some ancient city. If the observer of social phenomena could view the surface confusions of our times with a similar detachment he would doubtless be able to trace the outlines of a new civilization.

Consider, for example, the shifting emphases of politics. Within a generation concern for economic well-being has pushed concern for individual rights into the background in America; the State has become less a sovereign and more the sum total of our economic interests; representation in government by geographical divisions has lost ground to representation by economic functions, so that the farm bloc and the manufacturers' lobby stand nearer to actual issues than do the Republican and the Democratic parties. Britain is striving to reshape her empire into an economic rather than a political structure, in a supreme effort to bring her industry once more abreast of her population. France and Germany are sinking their bitter animosities in a newly discovered sense of industrial interdependence. Central Europe, thwarted in war, bases its bid for a place in the sun on its genius in research and in the refining and fabricating of the basic materials of industry. Russia and Italy have made a clean sweep of the political order in their drastic efforts to overtake an era of machine technology. Meanwhile, the immense shadow of American financial and mechanical supremacy looms over all the world, and new forms of world organization are being agitated to meet the challenge.

One has only to contrast the economic statecraft of a Hoover or a MacDonald with the dynastic intrigues of a Henry VIII, to realize how profoundly altered are the controlling forces in civilization. The world's population has doubled in less than a century and its material wants have increased many-fold. Over large areas the pressure of populations against space and resources has reached a critical level. History is being recast in terms of a struggle for fuel, ore, and fertilizer, of competition for world markets and sea-borne trade, of a race for supremacy in machine production. The weapons of this struggle are not forged in arsenals, but in the laboratories of patient and often obscure scientists.

Science is as old as the race, but the effective organization of science is new. The ancients did not lack for ingenious researchers; more than sixty centuries ago the Egyptians had fixed the length of the solar year to within one part in ten thousand; and eighteen centuries before Galileo an Alexandrian Greek proved conclusively that the earth is a sphere and measured its diameter with less than fifty miles of error. The ancient researchers, however, were isolated workers who kept few records. Little of their work survived the generation that produced it. Modern science had its beginning, a little more than three centuries back, when observers began to preserve detailed records and to organize co-operating groups for the exchange and criticism of their experiences. The power of science comes from its cumulative growth — the patient piling of fact upon fact, of measurement upon measurement, of effect upon cause, the work of a great army of investigators — far more than from some genius peculiar to the modern mind.

A second disruptive force fell on the old civilization when men began to cut across the slow changes of evolution in a spirit of deliberate innovation. The idea of progress by invention, so commonplace to us, stands out as profoundly revolutionary against the static philosophy of the Middle Ages. It could not have been mere chance that the era of science and invention dawned just as the golden age of geographical exploration was sinking into twilight, when the imagination of western Europe began to turn aside from treasure hunting, piracy, and conquest to the homlier arts of economic production. In her new quest of wealth, Europe needed a new philosophy and a new technique of progress. Exploring distant seas and remote continents had led to liberation of mind. Aristotle might hold his spell over cloistered minds in monasteries and universities, but not over men adventuring with nature. A new spirit of exploration arose, urging curious minds to voyages of discovery in the laboratory and the work-shop. Once science and invention were joined — for the two grew up largely apart — the new philosophy, the new method of progress was found. Says Whitehead of this event:

> The greatest invention of the 19th century was the invention of the method of invention. A new method entered into life. In order to understand our epoch we can neglect all the details of change, such as railways, telegraphs, radios, spinning machines, synthetic dyes. We must concentrate on the method itself. That is the real novelty which has broken up the foundations of the old civilization.

The early devotees of science had been amateurs, each working privately with such means as he could provide. It was a long step forward when first France, and soon after the other nations of western Europe, recognized that science must be professionalized and given a special place of nurture in the institutions of society. Science had to be divorced from the black arts, brought out of the cellar and garret, established in the laboratory, and given public support. Tentative efforts late in the eighteenth century to make a home for science in the ancient universities fared badly, on the whole; the new disciplines were too threatening to the closed system of knowledge carried over from the Middle Ages. A few special schools designed to advance certain scientific arts, such as the *École des Mines* of Paris, fared little better. Institutional science, in fact, had little secure standing before the French Revolution. The ideologues of the Convention looked to science to become the emancipator of society. At once they projected an ambitious scheme of scientific schools throughout France, headed by a great central institution in Paris to train an élite of scientific technicians for the service of the State and of industry. The scheme was largely premature; the provincial *écoles centrales* failed, having no roots in the existing educational system, but the *École Polytechnique* of Paris won eternal renown as the first great seat of scientific research and teaching.

It was the Germans, however, who pushed professionalism in the search for knowledge and in the application of science to industry to its logical limits. The industrial revolution began in England, where the possibilities of modern technology were first realized by an energetic middle class. The Germans set themselves to mining the deeper veins of science. In doing so they transformed their universities from mere means of preserving and transmitting a received cultural heritage into agencies for creating new knowledge. They abolished haphazard methods of scholarship. Progress became a matter of systematic effort and did not wait on the advent of an occasional genius or a lucky discovery.

With professional science began specialization. The older discipline of learning had been highly unified. Francis Bacon had been able to lay claim to all knowledge as his sphere in the sixteenth century but the nineteenth applied the principle of the division of labor. An army of specialists began to break up knowledge into ever smaller fragments in order to pursue it more intensively. Knowledge multiplied amazingly, but the unity of life and thought which had marked the Middle Ages was lost and in its place came a myriad of divisions and compartmental systems. Today we are faced with the monumental task of reassembling knowledge in order to construct intellectual and spiritual forces equal to the problems of our complex social order. We have found the specialist efficient in producing knowledge but need the generalist to put it to work.

The nineteenth century not only professionalized the work of scientific discovery, but that of scientific application as well. The engineer, traditionally a builder of highways, bridges, aqueducts, and fortifications, enlarged his field to include the application of science to economic production. Civilian engineering separated from military and at once began to expand and subdivide. So continually has engineering been bursting through traditional bounds, incorporating new areas of science and taking on new functions in the economic order, that it has become quite impossible to define engineering in terms of special forms of knowledge or the engineer by particular forms of work.

In a broad sense engineering is the application of the resources of science to the solution of concrete problems under strict economic control. The engineer is more a synthesist than a specialist; he is not a scientist, but one skilled in using scientific tools; he is not an economist, but one who solves concrete problems of economy; he is not a psychologist or sociologist, but one who organizes human labor systematically. The immediate aim of engineering effort is to attain the highest ratio of utility to cost; in the background stands the ultimate aim of human service and the engineer's striving for economy is always tempered in some degree by considerations of social welfare. These social aspects of the engineer's work are now beginning to assume primary importance. In the drama of civilization the engineer is being called from manipulating the mechanical properties in the wings to play a leading rôle — hero or villain — in the centre of the stage. For the first time in history he is conspicuously in the public eye and the public is wondering what special fitness he may have to deal with human destinies.

Hitherto the education of researchers and engineers has never caught the public interest, as has the education of physicians and lawyers. Few realize that from the beginning scientific education has been professional in aim and spirit, in contrast to the traditional liberal arts which aimed originally to give the student a unified view of life rather than specific forms of skill and knowledge. Science made its way into American education against determined opposition from advocates of the older discipline. In the post-Revolutionary period a little coterie of intellectuals, including men like Franklin and Jefferson who had come under French influence, visioned the spiritual and economic possibilities of science and labored actively for its advancement. The colleges which had been founded in colonial days on mediæval models were either indifferent or hostile to the new learning and deaf to the clamor of the struggling states, newly thrown on their own resources, for scientific aids to production.

The initiative passed to private hands. How often are the children of this world wiser in their generation than the children of light! The first American school of science to survive was founded at Troy, N. Y., in 1823 under the patronage of Stephen Van Rensselaer, landowner, capitalist, and leader in public affairs,

> for the purpose of instructing persons who may choose to apply themselves in the application of science to the common purposes of life. My principal object is to qualify teachers for instructing the sons and daughters of farmers and mechanics, by lectures or otherwise, in the application of experimental chemistry, philosophy and natural history to agriculture, domestic economy, the arts and manufactures.

The guiding genius of the school was one Amos Eaton who had been employed by Van Rensselaer to make certain surveys in connection with the Erie Canal and who had greatly impressed his client by his scientific capacity and practical sagacity. As a lawyer, civil engineer, geologist, chemist, botanist, and educational pioneer, Eaton combined a Baconian versatility in science with a Yankee genius for practical affairs. Rensselaer was in large measure the fountainhead of early American science, sending its graduates into the newly developing universities, east and west.

The original course of study covered a single year, being intended for men of considerable maturity and education. Rensselaer might have evolved as a graduate school for the training of teachers but for one circumstance, the coming of the railroad. With it came a demand for engineers versed in fairly exact arts of location and construction. The traditional British method of training engineers by individual pupilage was impracticable in a new country without a body of established practitioners. Out of this necessity arose the engineering school. Rensselaer was quick to assume this rôle; within twelve years of its founding it had a well-integrated engineering curriculum, the first in the English-speaking world. Eaton's successor reorganized the school after the model of the then dominant schools of Paris, setting as his ideal "a discipline complete in itself, not narrowly utilitarian, but adapted to the complete realization of true educational culture." The plan of studies was first lengthened to three years, and soon after to four, with entrance and graduation levels differing but little from those of the long-established arts colleges. The curriculum, however, omitted the ancient languages and put great stress on mathematics, graphics, the physical sciences, English, modern languages, and moral philosophy, as well as technical branches. This early programme of engineering was the first effective challenge in the history of our higher education to the long-standing monopoly of the classics and was the first programme to centre around a form of economic activity rather than an ideal of literary and philosophical culture.

The early ideals of Rensselaer for a self-contained, but not narrowly utilitarian education for engineers have since become widely established among the higher institutions. Engineers have not looked kindly on efforts to segregate the engineering course into a purely technical discipline, preceded by a lengthened academic education. Their ideal of an integral education may be likened to a rope composed of four strands running through its length, one humanistic, one scientific, one economic, and one technical, all firmly twisted in a fashion fitted to the economic function of the engineer.

For all the criticism visited upon it by the forces of tradition, the early engineering curriculum was a fairly liberal affair. Employers of graduates often dubbed it impractical. "Very well," said the teachers, "let us show them how practical we can be." Then followed thirty years in which shops and laboratories were multiplied and the operations of industry were simulated, as closely as might be, on college premises. The curriculm grew ever more technical, more specialized, and more crowded with detail. Since 1900 there has been a swing to a more fundamental and more liberal programme. Humanistic studies have multiplied and the details of practice have been left increasingly to the after-college apprenticeship. Meanwhile science and technics have expanded immensely and despite all effort to choose subject matters for their functional values and to intensify schedules so that the equivalent of five ordinary academic years of work may be encompassed in four, the programme is everywhere judged to be both overcrowded and incomplete.

Why not insist on a five- or a six-year course? Examined critically, this remedy is artifically simple. The young engineer is not as a rule book-minded; he is perhaps better classified as a "learner" than as a "student." A four-year course, beginning at nineteen or before and about equally divided between didactic and practical instruction, has been found well adapted psychologically to the prevailing type. For many, a longer continuous period would lead to diminishing returns. Engineers the world around want the novice in touch with the practical realities of industry by the age of twenty-three, unless he is distinctively of a "research type," in which case a longer training is favored. Naturally, in so limited a period, much that is desirable must be sacrificed if what is essential is to be well done.

While the four-year graduate bids fair to remain the backbone of the profession, engineers everywhere are recognizing the demand for men trained more profoundly in science and for men prepared for broader social responsibilities. The profession, however, is one of many levels, with its work and setting of such a nature as to insure the presence of a large rank and file engaged in fairly subordinate capacities. There is room for many a one-talent man for every five-talent leader or ten-talent genius. The problem is not so much one of excluding mediocrity, as one of attracting and cultivating superior men in fair numbers.

The realistic answer to the problem is to provide for all engineers a basic stage of training in essentials, universally accessible, and to extend it by a higher stage of professional training of much more selective character. For many, this latter stage will fall in what is now the after-college period. Within a decade we may confidently expect to see great numbers of young engineers in the twenties and early thirties, after an initial period of orientation to practice, returning to their studies for this higher training; some as full-time or part-time students in graduate schools, some in late afternoon or early evening classes, some in special schools conducted by employing industries, and others, less favorably located, in correspondence divisions. Some will pursue higher studies and researches in science, some the more specialized technique of engineering, some higher courses in economics and business, and many a broader understanding of essentially humanistic problems.

Back of this varied plan of further education one would like to see the guiding and inspiring hand of the organized profession, urging men on to some level of professional certification considerably above that of college graduation. As yet the profession has set up no code of educational qualifications, nor has the public at large begun to impress its will on the training of engineers. Apparently the public has seen little need for concern — did not engineers bespeak their competency by their works on every hand? Once aware that engineers, by their economic control of resources and production, hold human destiny in their hands, society may be trusted to see to it that they shall bring to their work not only scientific skill, but also social intelligence of a high order.

If one may venture to predict, the heaviest burdens to be laid on the engineer in coming decades will be the duty to foresee and in due measure control for beneficent ends the social consequences of research, invention, and advances in the technics of production. Machine technology, from its beginnings in the industrial revolution, has shown both a sinister and a benign side. It is still hard to say whether mass production is a blessing or a menace. The laissez-faire doctrine left science and technics free to run their course, assuming that moral insight would somehow keep in pace with the mastery of material nature. That assumption is now discredited; mechanical forces have plainly outdistanced moral and social controls. Physical science has left social science far in the rear. We have the power of supermen over "things and their forces," but only a faulty understanding of "men and their ways." Through machinery we command in America the labors of five billion slaves. One modern turbine alone is equivalent to two and a half million of them. Mankind, however, has yet to prove that it can remain permanently civilized. Can a machine civilization survive unless its architects are sensitized to human instincts and to social values? We dare not run the risk.

Probably nothing in modern education is more obviously efficient than the training of scientists as research specialists. Once despised and rejected by the academic mind, science now commands a vast prestige. Every branch of learning wants to be known as a science and every scholar as a scientist. The method of subdivision and specialization has been carried over into all areas of learning. An army of specialists has routed the humanist from the academic groves, and the old discipline of the liberal arts which aimed to give the student a unified conception of life has been replaced with myriad fragments of knowledge, often without underlying form or pattern. A chorus of youthful critics complains of an education which informs but does not enlighten. Men are perceiving that the organization by which we pursue knowledge most efficiently is not efficient for applying it. If education is to lead youth to an understanding of life we must bring back the generalist. If our vastly multiplied knowledge is to be used to rebuild society, we shall need the synthesist.

The new Institute of Human Relations at Yale is symptomatic of this new ideal of synthesis. Anatomy, physiology, neurology, biochemistry, psychology, sociology, economics, politics, ethics, and religion all have contributions to make to the art of living as a society, yet each avails little in the form of specialized knowledge; the mind of the researcher is in too sharp focus for every-day uses. New syntheses which cut across research fields are needed if we are to have effective social engineering.

The marks of the New Age on education in its more general sense are naturally of broader interest than the special training of researchers and technicians. Modern philosophy conceives of education as adjustment to life. What kind of life? The new era covers so short an interval of the race history that our philosophy of living has scarcely become adapted to it. If we were to picture the whole span of human history in terms of a man's lifetime, it is as if he began only two weeks ago to inquire systematically into the ways of nature, strive to improve his tools and processes, or take an absorbing interest in the production of goods. Naturally, the new scheme of life seems awkward.

The most obvious fact of present-day America is a vastly increased capacity for production. Today our factories produce thirty-three times as much as they did fifty years ago and our mines and oil-wells thirteen times as much. We produce twice as much per person as in 1900 and do it with far less human labor. The automobile of today represents only a third of the human work of the car of 1914. The man in the street has five times the income and twenty times the wealth of the American of 1790. With one-twentieth of the world's habitable area and one-sixteenth of its population, the United States holds more than one-third of its total wealth. A day's work in Philadelphia earns nearly twice as much of life's necessities as a day's work in Manchester, Amsterdam, or Stockholm, three times as much as in Paris or Prague and four times as much as in Warsaw or Naples.

Nor has the climax been reached, or perhaps even imagined. Engineers agree that production is only half efficient with present equipment, with undreamed-of gains still to come from invention and research. With incentive our agricultural output could easily be doubled, or even quadrupled. So far as science and engineering are concerned we could readily produce an abundance for our entire population, enough to remove all economic need for the labor of adolescents and the aged. Few realize how close to our reach is the abolition of poverty; the problem in the way is one of reorganizing distribution and the use of capital.

Great as the dividends of productivity in goods and money have become, we can scarcely expect to increase them indefinitely. We must expect to take much of our further gain in growing dividends of leisure, of cultural opportunity, of art and of beauty. We must expect the twenty-four hour working week and a thirty-five year span of productive labor. All our social ideals are being profoundly altered by the expectation of material abundance. None of the ancient philosophies contemplated any such thing. Their higher blessings were for the few. Aristocracy arose as an inevitable concomitant of crowded populations, scanty production and meagre resources; democracy has its roots in the expectation of enough to go around. It is no coincidence that the rise of democracy covers the same three centuries as the rise of science and technology. The new slave civilization subdues nature and multiplies producing-power fifty fold. By submitting to the discipline of industry for a fraction of his waking hours the worker gains undreamed-of freedom in all other areas of life.

Blended with these new economic premises of education are certain traditions carried over from pioneer life. We still think of men as scarce, of space and natural resources as abundant. Where Europe is prodigal of labor and thrifty with materials, we save labor and spend fuel, ore, timber, and soil lavishly. European workers are trained in superior craftsmanship, while our aim is to specialize machines and to make men versatile. Our economic system has exceptional resiliency. We accept as a matter of course dislocations which would shake old world societies to their foundations. The first aim of our education is adaptability; specialized skills we regard as of only incidental importance.

Given these abundant means and these new conceptions, we are able for the first time in the experience of the race to attempt the experiment of discovering, developing, and using to the full the potential capacities of all our youth. Given economic intelligence equal to our technical skill, and the burden of production may be lifted from the years of adolescence entirely. The use of talent, it seems clear, can not be wholly — perhaps not even largely — in the realm of economic production or professional service. What we sometimes think of as the by-products of life may become its chief preoccupations. Education, instead of being chiefly a training for economic labor to follow, is being conceived as a normal process of youthful living, a voyage of self-discovery, an adventure amid life interests, a discipline of creative talents, a quest for understanding of self and life. So progressive educationists dream. Utopian as the ideal may seem, the experiment has actually been started. As yet only the United States can afford it. Great Britain is harassed by over-population; France has a stratified social order and looks for hereditary exceptions only in the Mendelian ratio; German poverty demands specific vocational capacity as the predetermined end of every educational programme; Italy's and Japan's populations press ten times as hard against space and resources as our own. Nothing in American life leaves the visitor from abroad more dazed than our conceptions of education. To open the secondary school to every normal youth, to add to it the free junior college, to leave university admissions unrestricted, to test abilities in order to treat youth individually, to enrich the curriculum beyond recognition, to set formal discipline aside for creative self-expression, to assume that each individual may find life interests on the level of his highest powers — who can comprehend such a country?

The experiment, however, is too new to work efficiently. Meanwhile the distinctly intellectual processes in our education have fared none too well. Whatever youth may have gained in its adjustment to common life situations, astonishingly few products of our public education can reason accurately, express themselves lucidly, use a foreign tongue with any facility, read with appreciation any literature of enduring value, know any science worthy of the name, or employ any of the tools of analytical thinking. As for any general training of the mind as an instrument of thought, what the French call *la formation de l'esprit* and do notably well, it has been banished from the vocabulary as a relic of a discredited formal discipline. In its place we have such slogans as "the specificity of all learning." School tends to resemble the department store and learning a shopping tour. Young persons entering upon the disciplines preparatory to the more exacting professions too often find to their dismay that their mental tools are but crudely forged of untempered metal and incapable of holding a cutting edge.

Rich as our education is in its opportunities to explore cultural interests, another large section of our youth is most inadequately served. We have done less than justice to the large group whose intelligence and creative interests find their natural expression through skill of hand. Perhaps we have been misled by our zeal for measuring and classifying intelligence. The testers seem to have followed a circle in their definitions — intelligence, we are told, is the thing their tests test! Actually, is it not plain to common sense that intelligence has diverse forms, one that finds its medium in words and symbols, another in materials and mechanisms, another in shrewd economic insight, another in response to social situations, and possibly many other forms as well? To narrow so universal a term to the first of these forms and so to give it a limited technical meaning, seems gratuitous and misleading. It is difficult to forecast the future of education for craftsmanship. Our most prized national tradition is one of versatility. Graduates of vocational schools often refuse to "stay put."

Another neglected group includes the millions of youth with below-average mental endowments, the inevitable discards of a linguistic-scientific-cultural educational system, which aims ultimately at the recruitment of a professional élite.

The swiftness of economic change forbids us longer to conceive of education as an episode of youth, a once-for-all preparation for life. Much of the current criticism of education seems to assume that it should anticipate the needs of a lifetime. We must expect to re-educate people. What is called "technological unemployment," the supercession of old vocations and processes by new, is a fact for individuals as well as business organizations to accept and to meet constructively. Business is learning to anticipate this risk through research; the individual by continuous education. Professional workers as well as hand laborers must expect to retrain at intervals. Formal education must have as its aim the command of the art of self-education — the understanding of one's own learning processes, the mastery of sources, the evaluation of authorities and the capacity for valid self-criticism.

Broad readjustments are to be expected between the juvenile and adult phases of education. For all its spectacular progress in the last decade, adult education has yet to find itself. It is still in the stage of filling in gaps and omissions. As Caswell Ellis aptly puts it, life is a succession of youths, each needing its distinctive process of training and readjustment. There is the youth of infancy, with elementary life processes to be mastered; the youth of adolescence with its unfolding of sex and its budding vocational interests; the youth of early maturity with its adjustments to marriage, economic responsibility, and parenthood; and the youth of the climacteric period, with its vista of the more serene years of later life.

What possibility of enrichment of life, due to the shortened years of economic labor, exceeds the harvest of its riper years? If the body is kept sound, the mind fertile and the power of adjustment in full vigor, possible adventures in disinterested activity in art, science, philosophy, poetry, travel, and social service offer the promise of a golden age of maturity. For example, the writer has a friend who on his retirement from a position of financial trust in the middle sixties has taken up painting with all the eager zest of youth and a second in the fifties who is deliberately shaping his business interests to yield him a margin of fifteen years of freedom for cherished welfare projects.

A striking example of the prestige of science is afforded by the present movement to invest education with scientific techniques. The result has been to enmesh education in statistical procedures. Reasoning by analogy from the physical sciences, educationists have held that assured progress rests on measurement, that measurement requires units and scales, and that units demand objective definitions of concepts and terms. Experimental evidence, gained mostly from young children, indicates that much of learning is specific, hence measurable. Statistical observation, begun with the feeble-minded by Binet and Simon, later extended to a complete cross-section of the population through the army intelligence tests and finally applied to groups of exceptional talents by Terman and others, has indicated that educability itself can be measured. Now psychologists are on the trail of educabilities in particular, rather than educability in general. Hence a vast science, largely American in origin.

A genuine foundation exists for a science of educational measurement, but much that is offered is plainly pseudo-science. Educationists are very ambitious for the prestige of professional recognition by the public. Remembering the Shavian dictum, "Those who can, do; those who can't, teach!" educators desire keenly to create and possess special techniques which, like those of the physician, may serve as the hallmark of a distinctive status. In the present rush to be technical, the traditional artistry of teaching, a subtler thing less capable of objective valuation, has suffered no little eclipse. Science, like the term "profession," has come to have eulogistic values which everyone wishes to share. Teachers' colleges by their stress on psychology and technique under numerous names and guises, have tended to lessen respect for content and to exalt method in its place, with the result that "many who know little about their subjects, are attempting to teach them expertly." The teacher's retort is that modern education is "pupil-centred," rather than "subject-centred." So there!

On the whole, the teaching profession has made striking progress in the past two decades. The gain is the more remarkable in view of the strains imposed by the vast expansion of secondary and higher education since 1900. In the interim there has been a seven-fold increase, relative to population in high school enrollments and four-fold in attendance at colleges, universities, and professional schools. This expansion has been carried through with little regard to the availability of qualified personnel. It has seemed so imperative to assure the social assimilation of the children of our heterogeneous population, so new to our soil and institutions, that schools have been multiplied and expanded irrespective of the supply of teachers. Much of this expansion, like watered stock, has been a process of dilution, but solid equities are gradually replacing inflated values.

The methods used in upgrading personnel have sometimes been bureaucratic. So many colleges, bent on achieving the forms if not the substance of academic respectability, have treated the degree of Doctor of Philosophy as a union card in a closed shop, that its significance as a testimonial of special qualifications in original scholarship and research has been largely lost or obscured. Secondary schools have treated credits for post-graduate study as coupons, convertible into prescribed salary increases, until many a graduate school has nearly lost its scholarly character. Researchers have been put into places where teachers were supremely needed and the fragmentation of knowledge carried to extreme lengths where reconstructive syntheses were most of all to be desired. Youth is hard to trick, however, and many a college is a more sincere and wholesome place for a debunking youth movement.

In the face of three decades of such expansion, it is pertinent to question whether the movement for free higher education has any natural limits ahead. There are signs that a new equilibrium is being approached. Overcrowding of professions and white-collar callings, in the face of the high earnings of the better-organized crafts, has an undoubted influence. Why be a $40-a-week clerk if one can be a $15-a-day plumber? In an older and simpler day when many of our colleges were founded, higher education led largely to "services in church and state" and other semi-idealistic callings, modestly paid. Tuitions were scaled low, as an incentive to gifted youth, and scholarships multiplied for the needy. The Land-Grant Act of the Congress of 1862, to aid the states in establishing "colleges of agriculture and the mechanic arts" for the "liberal and practical education of the industrial classes" gave free public higher education its greatest impetus. In recent years the movement has reached its climax in the mid-western and far-western states. The dozen states which send the largest proportions of their children to college all lie west of the Mississippi.

States which have had occasion to telescope the entire course of social evolution, from breaking sod to the complex system of economic interchanges, into fifty years or less have necessarily faced the problem of making over each new generation with abnormal rapidity. As a more stabilized economic order is reached, such as that of the older states of the East, much of this public zeal for unlimited higher education will probably disappear. There is a growing conviction that the student who pursues higher education largely for personal economic advantage should more largely pay its costs, either as a current or a deferred charge. Alternating work-study programmes, tuition-loan systems, and self-help institutions would suffice to keep the door of opportunity open to every deserving youth, willing to face the odds of his own future.

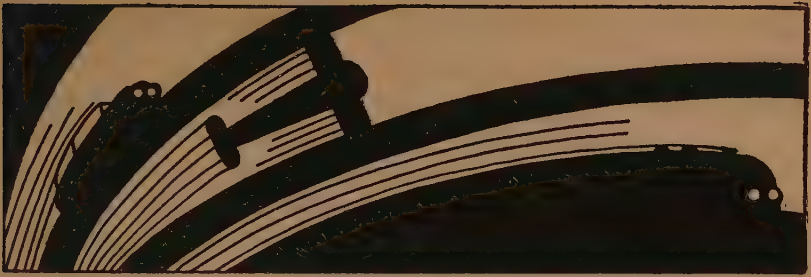
With widely diffused wealth and diminishing need for the labor of adolescents comes a rising demand for "college advantages," much of it frankly social rather than intellectual in aim. There is a growing conviction that this desire for more extended general education, as distinct from higher professional training, should be met in the secondary schools rather than the higher institutions. The junior college appears to be a transition agency pointing to this end. Its two-year programme is as yet merely a truncated college curriculum, but it bids fair to acquire a more distinctly terminal character with a goal comparable to the *baccalauréat* of France or the higher school certificate of England. There is at present a considerable age differential, due to the slack pace of a scheme of secondary education intended for all, rather than a selected group, which delays this goal to the age of twenty or twenty-one in America, where it is commonly reached at eighteen or nineteen abroad. Until this slack has been taken out the colleges devoted to technical education are likely to hold to their present entrance levels rather than to give over their first two years to junior institutions. In the judgment of educationists the junior college represents the present limit of general education which it is economically practicable to provide for the great body of our adolescent population.

The public may take comfort in the observation that the worst of the growing pains — and possibly costs — of our educational development are over. School and college enrollments are tending to assume a more stable ratio to population. An immense amount of costly plant has been built and need not be replaced for a generation. Teaching is on the gain in prestige and gives promise of reaching parity with research. The limitations of specialization stand revealed, and a new period of synthesis is developing. A saner balance between study, sport, and organized activity is manifest in the older institutions. Selective standards of admission to college are reacting as a stimulus to superior intellectual effort in secondary schools. Self-motivating students are being freed from routine discipline for autonomous work. A public hitherto more zealous to extend the quantity of education is at last growing concerned with quality, as men recognize that the safety of a democratic society hangs no less on an élite of leadership than on equality of opportunity.

If we are to use to the full the latent powers of all our youth, it seems unlikely that more than a minor fraction can be absorbed in the work of supplying economic needs. Education centred in this ideal of full use must work with an eye to the pursuits of leisure. There is a special timeliness in the rising interest in the fine arts, especially as avocations. From the cultural view-point the characteristic defect of scientific pursuits is that they deal with the universe in fragments. The field of view tends to grow microscopic. Art, which seeks to see life whole and to reveal its universal values through symbolic forms, is an ideal counterpoise to science. The higher professions make an ever-rising demand on creative imagination; running a business or directing a technical industry involves artistry aplenty; but the great body of workers have lost even the vestiges of a varied and creative craftsmanship. For the millions, the expression of individuality belongs to leisure rather than to work.

The burden of establishing a great cultural heritage in American life properly belongs to the present generation. Our vast gains in wealth are only half due to science and technology; prodigal consumption of coal, ore, oil, timber, and soil accounts for the other half. Much of this natural wealth we are powerless to replace — sunk without a trace. Future generations will find a good living just so much harder to make. It may be hard to justify this prodigality to posterity unless the present lays the foundation of a worthy cultural heritage. If history teaches anything clearly it is that only a spiritual residuum survives from one age to another. The significant period in European culture which we call the Renaissance bears a striking witness to the influence on society of the intellectual climate in which its leaders develop. May not an equally epochal change be expected from the accumulations of these three centuries of scientific inquiry? A fertilizing principle alone can scarcely create a new culture; there is need of an environment favoring its incubation — a margin of knowledge, of wealth, and of leisure, a sense of social security, and, most of all perhaps, a unifying philosophy of life and society. How striking the unity of the thirteenth century in contrast to the chaos of the nineteenth!

But may we not be on the threshold of another great unifying epoch? One can scarcely speak of a renaissance of American culture, for an indigenous culture is yet to be born. Our earlier transplanted culture — that of Emerson and of Poe — could not survive apart from the English soil whence it came. There is hope for a great creative epoch in the fresh, untrammelled attitudes of our youth, the first generation to grow to maturity under the full sway of the spirit of science, and freed from the labors of subduing a continent which fell so heavily upon their fathers. Is mechanization inimical to the "good life"? Has the economic advance of the Twenties been fatal to the spirit? We can not believe it so. With the possibility of banishing poverty now in our grasp, with the victory over disease ever more certain, with knowledge being reunited from the fragments of specialization, with the best intelligence of the race at work forging the instruments of peace, intuitively we sense the coming of great events in the spiritual history of mankind. The spirit which reared the Acropolis above Athens, the spirit which reared the cathedrals of northern Europe for sheer joy of creation, will live again, clothing the age of power and machines with its own intrinsic beauty.



XIV — MACHINE INDUSTRY AND IDEALISM

By Michael Pupin

IT IS the fashion of those who criticize our industrial society based on science and machinery to assume that an agricultural civilization is more idealistic than ours. Many essays and books have been written on this theme in the abstract, but it seems to me that the controversy can best be illuminated by a consideration of concrete cases. It is one thing to theorize about types of civilization and another thing to have experience, and my experience extends into the two orders of society.

Nine years ago I was invited by the Serbian Government to study the condition of the Serbian war orphans, and I accepted the invitation. A Ford car, a Serbian soldier as chauffeur, and a young priest as guide assisted me in the performance of my mission.

One day as we speeded along a stretch of a narrow level road in the southwest corner of Serbia I saw in the distance a Serbian peasant with his oxen and cart standing by the side of the road and waiting for my machine to pass. When I got near him I stopped, got out, and shook his hand, thanking him for the courtesy. "Oh, don't thank me," said he; "this is the least that I can do for an American. You Americans have been most kind and generous to us Serbians during the recent war. You banished typhus from Serbia and we shall never forget it." "But how do you know that I am an American," asked I, and he answered: "Your looks and your language suggest a Serbian, but your manner is different. No European of your class has your manner; it is the cordial and gentle manner of the Americans who came to aid us during the war.

"Besides, no Serbian can afford today the luxury of an automobile, nor is he in sufficient hurry to need its speedy service. This cart with its slowly moving oxen is speedy enough for me." "But you are not going very far," said I. "To Belgrade," said he; "I shall be there in a fortnight, whereas you probably left Belgrade yesterday morning. You, like all Americans, are in a hurry; I, like all Serbians, am not. After sellng these ten bags of tar it will take me two weeks more to return to my farm on the slope of that mountain over there." "But how can you spare the time at this busy summer season?" asked I, and he answered: "I have just finished the hoeing of my corn-field, and by the time the harvest season is on I shall be home again. Time is not so very precious to us peasants until a week or so after Saint Peter's day." "But the travelling expenses of your four weeks' journey will eat up all the proceeds from the sale of your ten bags of tar," said I, and he answered: "I have no travelling expenses. This time of the year my oxen and I sleep out under the canopy of heaven; my friends and acquaintances along the route will feed me and my faithful oxen. Half a loaf of black bread and a raw onion or two are my daily diet on these journeys; there are juicy pastures on every side for my oxen. In exchange for their hospitality I shall give my friends several new tunes of my flute and recite several new ballads which I recently learned from the shepherds on my mountainside. My friends, on whom I expect to call, undoubtedly have similar treasures of new tunes and ballads, and they will not begrudge me a tiny share of them. While wandering slowly in daytime I shall have plenty of leisure to explore again the beauties of dear old Serbia; at night I shall rejoice in the glory of the blazing stars, which to me are like the eyes of God watching over the destiny of my beloved Serbia, just as they watched during this recent war. You see, then, that when I get home again I shall have all the dinars which Belgrade gave me for my ten bags of tar, and my dearly beloved oxen will be slicker than ever. Besides, my flute will be richer by several tunes and my heart will be fuller than ever with love for my beautiful Serbia."

One can imagine how these sentiments of the sturdy peasant thrilled me! His idealism recalled the days of my early youth among the peasants of my native village. I could not help making a confession to him, and said: "My father was a Serbian peasant just like you; he had a yoke of oxen just like yours; in my boyhood days I drove them, and I was just as fond of them as you are of yours. Then I deserted them and ran away to America." "Oh, how could you desert your lovely animals and run away to the land of machines? Are you not sorry today that you did it?" asked he, but I gave him no answer.

I had no ready answer which would have been intelligible to an idealist like that Serbian peasant. I was quite certain, however, that he did not refer to "the land of machines" in a disparaging sense. He obviously saw a halo around this land of machines, because his experience had told him that it produced men and women who had cordial and gentle manners and rendered voluntary service to suffering Serbia. I did not answer his question, but I have been thinking about it ever since, and I have been trying to answer it to myself.

Yes, there was a time when I was sorry that I had deserted those lovely animals and had run away to the land of machines, as that Serbian peasant called it. I missed the gentle spirit of my humble peasant home and of its patron saint. I missed the thrills of the Serbian flute, of the Serbian ballads, of the blazing stars in the Serbian heavens, and of the honey-hearted accents of my village chums. In short, I missed the very things which that peasant idealist prized so highly. But gradually I became reconciled; America gave me many, many thrills which I should never have experienced in my native village.

Just think of the thrills which I experienced during the earliest days after my landing at Castle Garden! There was the awe-inspiring elevated railroad and the embryo of the Brooklyn Bridge spinning out its span of slender wires like a spider's web high up in the air and across the East River.

Two years after my landing I saw the first telephone exhibited at the Centennial Exposition in Philadelphia. It repeated speech with perfect articulation. This was a great thrill to everybody and particularly to an untutored immigrant like me, but it nearly persuaded me to go back to my native village. "No chance for me," said I, "in this country of magic, where men can make a simple steel disk speak the English language better than a Serbian greenhorn can speak it in spite of all the efforts of his clumsy vocal organs."

Two years later I experienced a similar thrill when I first listened to a phonograph. Edison's incandescent electrical lighting of 1882 mystified me and filled me with awe when I compared it with the tallow candles of my native village. I shall never forget my emotions when I first gazed at the blazing flames of the roaring furnaces in the Pittsburgh steel district where millions of tons of steel were preparing the foundation of a new civilization. These and many other apparently miraculous workings of science and invention, witnessed by my untutored and impressionable mind, consoled me for what I had lost when I deserted the lovely animals of my native village and ran away to the land of machines. But this was many years ago; do they still console me today ?

Revolutionary changes have been created by science and inventions the beginnings of which thrilled me during my early American career. They certainly have transformed this land into a land of machines, and most of these transformations took place since I landed here fifty-four years ago. What can I say today about their influence upon our American civilization and upon our individual souls, in order to convince that Serbian peasant idealist that I made no mistake when I deserted my beloved Serbian oxen and ran away to the land of machines?

The European observer who comes here and, after looking around for a little while, writes elaborate essays about American materialism would not hesitate to say that I made a lamentable mistake. He will tell you that as far as this country is concerned the result of all the advancements in science and inventions is an American civilization of industrialism of which Henry Ford is the patron saint. Mass production in everything, says this superficial European observer, is the highest aim of our civilization: millions of tons of steel in Pittsburgh and Gary; millions of automobiles in Detroit; countless heaps of machine-made shoes in Lowell. Nay, mass production even in the educational field, where endless droves of crude bachelors of arts are let loose annually from our American colleges. It is one of these superficial European observers of America who credited Ford with the statement that he will take no interest in old masters until he can manufacture by the millions their finest pictures and distribute them free of charge among his customers. This alleged statement is, of course, a libel upon Mr. Ford. It is indirectly a libel upon all our American captains of industry. Yet there are some American pessimists who heartily indorse that view. If I accepted that view of the superficial European observer and of the American pessimists, I should be sorry indeed that fifty-four years ago I deserted my dearly beloved Serbian oxen and, as the Serbian peasant expressed it, ran away to the land of machines. But I do not accept it; my American experience of fifty-four years rebels against it.

That Serbian peasant had a much more cheerful picture of this land of machines; how could he help it when he remembered that this land of machines produces gentle folks, cordial and generous in their manner, ready to offer unselfish service to suffering humanity ? Nothing in their conduct suggested to him that the land of machines is a land of materialism. He knew that back of these American machines, and back of our proverbial hustling and hurry, there is a gentle spirit which he had not observed among the great folks of Europe whom he had seen in Serbia during the war. Here, then, is a secret which the superficial European student of America will never fathom. My experience of fifty-four years in America and my knowledge of the simple idealism of the Serbian peasant entitle me to the privilege of saying a word or two concerning this secret.

The secret is not revealed to the European observer of American civilization by things which one sees on the surface of our metropolitan life, nor by what one sees and hears at the bridge-whist tables of the palaces at Newport; one must look for it in the American homes of smaller pretensions. Litchfield, Amherst, Pasadena, Oakland, and countless other real nurseries of American life in any part of these United States will reveal it to the vision of the carefully trained European eye. But how can the European get that training? Every intelligent and experienced immigrant will say: Let him live in the United States until he feels at home. The untutored and impressionable mind of a young immigrant such as I was when I landed here is thrilled at first by the miracles of science and inventions in this land of machines. This was all that I saw during my greenhorn days. My mental vision was not equipped for seeing anything else; many casual European visitors and superficial students of American civilization remind me forcibly of my greenhorn days.

The struggling immigrant greenhorn begins to expand his vision and to orient himself in this new world when some guardian angel puts into his hand a history of America, the same guardian angel who left at young Lincoln's log-cabin home a history of the United states and Weems's "Life of Washington." The immigrant guided by his experience in American homes discovers then that in this land of machines there are other things which thrill the soul of man even more than the apparently miraculous inventions do. American history of the period preceding the Civil War led me to this discovery as long as fifty years ago, and it gradually persuaded me that the most thrilling part of the story of this land of machines is not revealed by the miracles of science and inventions and the industries to which they lead; but that it is told by the achievements of the souls of men who shaped the soul of this nation. This was the result of the process called Americanization; no European student of American civilization and culture should write elaborate essays about them until he has gone through this process.

When the impressionable mind of the young immigrant begins to understand the idealism of the colonists and of Washington, their leader, he begins to feel the heart-beat of the new world. It gradually ceases to be to him a strange, puzzling, and machine-made world, and his hope grows strong that he and his ancestral virtues and the simple idealism of his native peasant village will find a congenial home in this land of machines. Washington's ideal of the American Union becomes then his ideal, and he follows with breathless interest Marshall's, Henry Clay's, and Webster's defence of that ideal. Lincoln to him means the crowning victory of that ideal. He recognizes in the idealism of these men the root of a new idealism, the American idealism.

"This American idealism," the superficial European observer will say, "belongs to the period which started with Washington and ended with Lincoln. The materialism of the present period, the period of American industrialism, has smothered it." What does history say?

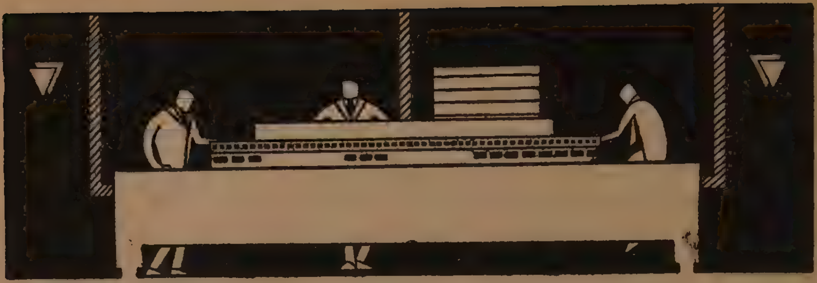
The greatest enlightenment awaits the immigrant as well as the European student of this land of machines in the study of American history relating to the period following the Civil War. I call this period the period of the American Renaissance. I was fortunate to watch and to understand its develpoment from its beginning. I saw the growth of the American industrialism during this period, but this industrialism never suggested to my mind the reign of materialism. There was a guiding spirit in this growth, the spirit of American idealism.

In the midst of the Civil War, in 1863, President Lincoln and his intimate friend Joseph Henry, the greatest American scientist of those days, founded the National Academy of Sciences. Its distinguished members, all idealists like Lincoln and Henry, soon started a movement for higher endeavor in all our intellectual pursuits. This movement is the American Renaissance. It succeeded beyond the rosiest expectations and gave us as its first contribution our American universities of today. Johns Hopkins, organized in 1876, was the earliest among them. Harvard, Columbia, Yale, Princeton, and others followed in rapid succession. They were American colleges only, and became American universities when their scientific research laboratories came into existence and began to cultivate the modern American spirit of scientific research. It is the spirit of the philosophy of scientific idealism, which has stood the test of many centuries. Call it the philosophy of the three "M's." Motive, mental attitude, and method of research are the three characteristics of this philosophy. The *motive* is unselfish search of the eternal truth; the *mental attitude* is open-minded and unprejudiced interpretation of the language of nature; the *method of research* is the method employing observation, experiment, and calculation. The idealism of this philosophy is simple, definite, and obvious. It is the idealism which guided Archimedes, Galileo, Newton, Franklin, Faraday, and all their disciples in their epoch-making scientific achievements for the benefit of mankind. The cultivation of this philosophy of scientific idealism was gradually transplanted during the last fifty years from the scientific research laboratories of our American universities to the research laboratories of our American industries. I witnessed this transplanting in every one of its phases. The philosophy of scientific idealism is today the bond of union between our industries and our universities. This is one of the greatest achievements of the American Renaissance which started sixty-five years ago, and contributed more to the reinforcement of Washington's and Lincoln's ideal of the American Union than all the other achievements of this period put together. It is our strongest arm of national defence. The miracles of science and of inventions of this period will long be forgotten when this welding of the American industries to the American universities will be still remembered as the greatest achievement of this age.

The great American industries, recognizing their obligation to pure science and to its guiding light, the philosophy of scientific idealism, are now creating a twenty-million-dollar fund to be expended in ten consecutive years in the cultivation of purely scientific research for the good of our American idealism in science.

Consider now the vast number of museums, picture-galleries, conservatories of music, philharmonic societies, institutions of higher learning, cathedrals, which, following in the path of advancing idealism in science, have come into existence during my American experience of fifty-four years; consider, moreover, that all these nurseries of the æsthetic and spiritual activities of the American soul were made possible by individual donations of private citizens, leaders of our American industrialism, and it will be obvious that the only materialism in this industrialism will be found in the material wealth which makes these nurseries of the idealism of American life possible. I cannot help seeing behind the American machines and American industrialism a spirit of that rare idealism which guided Washington, Lincoln, and other American leaders of men.

Every mediæval cathedral has a soul; it is a part of the soul of its designer and of the souls of the pious men who built it. So every modern machine has a soul; it is a part of the soul of its inventor and of the patient souls of the men who developed it. Who dare say that these souls are guided by a sordid spirit? Whenever you speak of this land as the land of machines, remember the machine and its pilot who with a honey-hearted smile carry our American message of goodwill to the nations of the earth. The gentle soul of the pilot is so closely welded to the soul of his machine that the union cannot be better described than by the affectionate title "We." There is, indeed, a noble spirit which controls this indissoluble union of souls. It is this spirit which moulded the souls of of the Americans whom the Serbian peasant admired so much. That Serbian peasant idealist believes, I am sure, that these souls are the spiritual leaders of the world. It is the communion with this spirit of idealism which makes me say today: I do not regret that fifty-four years ago I deserted my beloved Serbian oxen and ran away to the land of machines.



XV — SPIRIT AND CULTURE UNDER THE MACHINE

By Harvey N. Davis

I

SPIRIT and culture are difficult to define. The spirit, élan, dash of a man is an intangible something that spurs him on to eager activity, that makes him tackle his job with a confident smile, that adds a touch of gaiety and assurance to the serious business of life. It is that something that distinguishes the self-reliant leader from the plodding follower. As we look back over history, there must have been, in general, but little spirit among the slaves of antiquity, or among the mediæval land serfs, both of which groups formed large majorities of their respective populations. By contrast, the spirit of the corresponding classes of today is high indeed.

Culture is that which makes a man feel unembarrassed and at home wherever and with whomsoever he finds himself. One of the ingredients of culture is poise or self-possession. Another is responsiveness to worth-while impressions from without; responsiveness to ideas; responsiveness to beauty, whether it be the sensory beauty of a fine painting or a fine symphony, a fine cathedral or a fine skyscraper, or the intellectual beauty of style in writing and in speech, of wit and wisdom, of clearness in exposition, of keenness in debate, or of vision and inspiration in poetry. It is this responsiveness to impressions from without that can make life a continual joy to one who has eyes to see, ears to hear, and a heart to understand. A third ingredient of culture is tolerance, that happy faculty of respecting those with whom one happens not to see eye to eye, of instinctively finding good in them, of being more interested in understanding than in reforming them. And there are doubtless other ingredients of culture that the reader will add for himself. In general, one might say that as soon as primitive man began to go beyond the hectic and harassing struggle to obtain subsistence, and began to enjoy some of the elements of his environment, culture began.

There is another side of man's mental life that may be called character. This too is hard to define. A part of it is his instinctive code of ethics. Another part is his will. Still another is that group of qualities that include steadfastness, dependability, and loyalty.

So we have the spirit of mankind that brings liveliness and drive to all their contacts with each other and with the world; we have culture that brings poise and beauty and contentment; and we have character that adds the sterner virtues and often a beautiful serenity. These three, liberally interpreted, may be said to comprise the mental and spiritual side of life — they are, in essence, life itself. How are they faring under the machine?

II

WHAT is "the machine"? Two quite different aspects of our mechanistic age will be considered here. The first is the point of view, the spirit, of science. This affects men's minds directly. It is what has made the machine possible. We shall have much to say about it later on. The second is the economic custom called mass production. It affects men's minds only indirectly, by modifying the environment in which they think.

It is this second incarnation of "the machine" that seems to worry contemporary critics. Volumes have been written on the deadening effect of the Ford assembly line on the souls of noble Americans. More volumes have been written to bewail the disappearance of the mediæval craftsman, in the place of whom we now have only women, each of whom can keep sixteen looms in production during ninety per cent of an eight-hour day, and men who can run simultaneously half a dozen high-speed automatic turret lathes.

Individuality and beauty are supposed to be dying, and men (even including, so they say, Babe Ruth himself) are rapidly degenerating into utterly despicable mechanical robots.

I must confess that all this literature of pessimism leaves me singularly cold. Somehow it seems unconvincing. I find myself wondering if any one of the authors thereof *could* keep a battery of turret lathes on the job, even if he wanted to. I wonder if he *could* set up a turbine casting on a fifteen-foot boring mill so that, eight or ten hours later when the machine had finished its job, every flange-face and diaphragm bearing, every wall of shining fresh-cut metal, would be where it ought to be within an astonishingly small tolerance. I wonder if he *could* handle the throttle of an A-3 locomotive hauling the fifth section of the Century through the night at better than sixty miles an hour, with the fourth section not over three minutes ahead, and several hundred lives in his care. And if he could and did accomplish any one of these ordinary tasks of modern industry, I wonder if he would still write about the mechanization of men's souls. I wonder if he would not find himself suddenly possessed of a quite new sense of self-respect. I wonder if he would not realize that in each such job there is an artistry and a thrill quite comparable, in spiritual value, with anything mediæval craftsmanship could offer.

I feel, too, that the power of environment to warp the thought of men can easily be overemphasized. One of my friends brought back from the war a charming French wife. After she had been some time in America I asked her if, notwithstanding all the necessary readjustments, she was happy in so different an environment. "Why of course," she said. "It is not what is about one, but what one has inside one's own mind, that makes happiness." Men often are singularly independent of environment. Beethoven sang on through deafness, and the Wrights emerged in flight from comparative poverty. And on the other hand many a rich father would gladly purchase at any price an environment that would automatically produce a worth-while son. Great civilizations have flourished in Egypt, Mesopotamia, and India on the one hand, and in parts of Canada on the other that, a hundred years ago, were regarded as utterly uninhabitable because of the inhospitable cold.

In thinking about spirit and culture under the machine let us, then, never forget that the spirit and culture of the future are going to depend primarily on what is inside men and women rather than on what is about them, that the greatest need is for sound and wide-spread education and for real intellectual leadership, and that, with these, no plethora of machines can either cause, or prevent, the flowering of the best that human minds are inherently capable of producing. In the words of Milton:

> The mind is its own place and in itself
> Doth make a Heav'n of Hell, a Hell of Heav'n.

III

As has been said above, it is chiefly the mass-production side of the machine that has aroused contemporary criticism. And yet even Henry Ford's assembly line has much to be said for it.

In the first place, repetitive work is not nearly as repulsive to some people as some other people think. There are all sorts of temperaments in the world, and for certain of them contentment is easiest gained by routinizing one's occupations to the point where one doesn't have to worry about them. Nor are these temperaments to which repetitive work is not irksome by any means confined to people of low mentality. I, myself, and my father before me, have been among that not inconsiderable number who thoroughly enjoy a completely routinized piece of intricate numeral computation. The handling of several hundred thousand examination papers by the readers of the College Entrance Examination Board each June is, after the first day or two, a thoroughly routinized piece of repetitive work, and yet most of those who participate in it find it not unpleasant. I have been told by certain engineers, who have had occasion to sit in on assembly lines in connection with inspection or development work, that after the job is once mastered, the mental reaction may be far from deadening. One of them spoke of such an experience as the best chance he had ever had to think through a lot of things that had been crowded out of the busy mental life of the preceding months. And there is the familiar story of the man whose job it was to lie on his back under the

Ford assembly line and screw number fourteen nuts three and one-half turns to the right on the cars passing above him. When, at the insistence of a shocked observer, he was offered a change of work, he indignantly refused it. "I've got the best job in the factory," said he. "I'm the only man in the place that can lie down all day and still draw his pay." Such a man *may* have, not only a sense of humor, but a keen and comparatively rich mental life, fed by his activities outside of working hours. He may also have quite as good an opportunity to philosophize as any shepherd boy in a mountain pasture in Yugoslavia *if* he has a temperament suited to repetitive work. But it is of the utmost importance that the right group of workers be selected for such work. To a certain extent they select themselves, but when there are misfits the consequences are sometimes tragic.

A second favorable aspect of repetitive work is so obvious that it scarcely needs mentioning. Mass production tremendously increases the quantity of useful things in the world, and decreases the cost of them. This means a much higher standard of living even for the lowest quarter in the economic scale than has ever before been attainable by the corresponding fraction of mankind. It means that the necessary or desirable production of the world is being done in less and less time. The ten-hour day has replaced the twelve, and the eight-hour day has largely replaced the ten. The seven-day working week has dropped to six, to five and a half, and even, in some industries, to five. The producing power, and hence the consuming power, of the average man has doubled or trebled within the memory of living men. The average man has both more leisure and more opportunity to use this leisure to advantage. Whether it *will* be used to advantage or not depends, as I have said, solely on the mental resources of the average man, and on these the machine, as such, is likely to have very little influence. All that can surely be said either for or against the machine is that it is making possible (not probable — or improbable — but merely physically possible) a spirit and culture which, both in intensity and in depth of penetration into the masses of the population, can conceivably far outshine anything that the world has ever known.

The economic advantages of mass production to those engaged in it, are peculiarly marked with certain types below the average in mental vigor, who form an obviously appropriate part of the personnel assignable to repetitive jobs. The mental stolidity which is a distinct advantage in this sort of work would be an equally marked disadvantage in individualistic industry, and many such men and women would find it hard to earn a comfortable living in any other way.

A third fortunate aspect of mass production is that it is to so large an extent brainless production. There is a lot of drudgery in the world that will always have to be done if the consumers, who are largely also the producers, are to have what they need or desire. Is it not better that as much of this work as cannot be done completely by machines, should be done as largely as may be by hands and eyes that work as automatically as machines, while minds are free to roam at will, rather than that each individual monotonous act should be initiated and controlled by a constant exercise of the worker's judgment ? Psychologically it is not repetitive action that fatigues; it is rather the purposeful, conscious repetition of the guiding mental processes; and this is more and more reduced by the routinization of the procedure.

Furthermore, the routinization of a repetitive manual process is always a step toward its complete mechanization, and the more complete the routinization, the sooner is the machine likely to come. A hundred and fifty years ago the making of nails was entirely a home industry. The proprietor of the slitting mill brought the slit sheet around to the farms where each farmer had a nail shop adjoining his house. Here he and his sons, working in the bad weather and long winter evenings, hammered the nails out on a nail anvil. A little later, some genius invented the swage so that after the nail had been drawn out it could be placed in the swage and given a more or less standard shape. Shortly after, Read of Bridgewater invented the nail machine whereby the slit sheets were fed into the machine which cut the nails off the end of the sheet and headed them in an automatic operation. A man kept the cutting tools in order and a boy introduced new strips as they were used up. About 1885, one man and a boy worked two of these machines, but gradually the skill of the mechanic learned to grind the tools in such a fashion that they lasted much longer and instead of running two machines the workman ran six machines. About this time the wire nail machine was introduced, making the nail from a coil of wire in an automatic machine, and the introduction of high-speed steels and machine grinding has reduced the labor in the nail industry to a very small amount. This is an example of how mass production first routinized the manual process, then turned the mechanic who made the complete product into a tender of machines, and finally replaced him with an automatic machine requiring a man of very high skill to keep the machine in working order.

I realize that this replacement of men by machines raises many serious problems as to the proper distribution of the produced wealth of the world, and that individual transitions of this sort are likely to be accompanied by heart-rending misfortune for certain individual workmen. Any discussion of these difficulties belongs elsewhere. I can only say here that, even when they are taken fully into account, I have no question that the more and more complete mechanization of production that is under way is, on the whole, opening larger and larger opportunities in spirit and culture for the mass of mankind.

IV

THERE is, however, another side to the picture, a vague intangible side that may or may not carry conviction to the reader. And yet it should be carefully considered.

Mass production is essentially a speeding-up process. In part it rests on keeping materials and men moving. In part, also, it rests on eliminating unnecessary movements either of materials or by men. Both endeavors hasten the accomplishment of a desired result.

Mass production is also, as we have said, a thought-eliminating process. Repetitive jobs are so planned that human beings can perform them with the expenditure of the least possible amount of brain-power that will suffice. The minds of repetitive workers are, therefore, roving minds.

And, finally, mass production is intimately related to, if it does not inevitably breed, modern advertising, with all its visual jazz, its striking typography, its attention-claiming phrases and slogans, its constant effort to shock itself into the consciousness of the public.

Now there are certain mental characteristics of twentieth century Americans that are startlingly like these three characteristics of mass production. Our lives, even in our so-called leisure hours, our thoughts, our whole intellectual atmosphere, all these are hectically speeded up. When we get home of an evening do we settle down with a quiet smile to a thought-provoking or soul-enlarging book? No, we go to the movies, or to that gattling-gun variety of entertainment called a revue. We skim the headlines on the way to the office, and vote accordingly. On Sundays we rush about in cars at forty miles an hour (or more) cursing those ahead for blocking traffic. Or we play golf and yell "fore!" at every man we catch sight of. Or we flock to Coney Island and satiate ourselves with the thrills of all sorts of unusual bodily accelerations.

We have roving minds. The novel is being replaced by the short story, and the editorial page by the pictorial tabloid. The two-and three-hour orations of Chauncey Depew's prime have to be compressed into twenty minutes or nobody will listen. Leisurely thinking, which means, or at least may mean, deep, continuous, sustained thinking, is rare.

And, finally, our minds are becoming desensitized to ordinary impressions from without. We are building up not merely a sales-resistance but an ideas-resistance as well. Even a serious magazine like *The Forum* jazzes up its pages with arabesques and scrolls and decorated capitals in the belief that a striking typography is necessary to make any impression whatever on the ordinary mind. *The Thinker* fills its wide margins with a steady barrage of pithy summarizing sentences. And *Time* pecks away at our minds like a wood-pecker on a tin roof. Not that we are necessarily inhospitable to ideas once they rise above the threshold of consciousness. But the ordinary channels of communication are apparently breaking down, and it would seem that it takes a brass band of bombast, or at the very least a saxophone of pessimism, to attract our mental attention at all.

All this, if it is indeed a fair picture of the spirit and culture of America, is far from a happy one. Perhaps it is not fair to say that the speeding-up of mass production has caused the speeding-up of life, that the roving minds of the five per cent of us who are repetitive workers carry over a sort of contagion, not only into their own, but into everybody's leisure hours, and that even the masses would soon welcome sweetness and light if only the advertising could be stopped forever.

But even if, by reaffirming the belief that it is a confession of weakness to lay the blame for mental shortcomings on an unfavorable environment, we absolve mass production of the charge of having caused these unfortunate intellectual habits of our time, we can at least ask what the men who are guiding this mechanistic age can do to counteract them.

The speeding-up of life will probably be best attacked through education. Here we need more schoolrooms with fewer children in a room, and more schools with fewer rooms in a school. We need better teachers, better-paid teachers, teachers less harassed by life and by school and city politics. We need also teachers less harassed by "the system," teachers who are permitted to cover less ground more quietly and more thoroughly. And, as a start in this direction, the leaders in our colleges that top "the system" ought to forget a good half of the intricate detail of their admission requirements. We need also more music, and better music, in the everyday life of America, more parks and open spaces in our cities, more excursions to the country and more hot-dog-less places to make excursions to. We need more quiet hobbies, and more first-hand play, as distinguished from second-hand watching of other people's play. In a word we need deeper and more widely diffused culture, and this can come only through education.

The roving minds, not only of repetitive, but of all workers in factory or office could at least be refreshed by their surroundings. In some parts of the world, factory managers provide professional readers or musicians to occupy the minds of the girls who roll cigarettes; but this would hardly work amid the clatter of a punch-press room; and cigarette rolling in the United States is already completely mechanized anyway. A wave of aluminum paint is already spreading over factory interiors both here and abroad (somebody has proved that it "pays"), but even the newest of the aluminum-painted factories that I saw in Europe last summer still had ground glass in its ample windows, lest the workers should be tempted to look out. In general, any attempt to beautify, or even to make decently and attractively clean, the surroundings amid which men and women work is still regarded as insanity if it costs anything. That slogan of New England bill-boards, "Milk from Contented Cows," has never been stretched to include humans.

Some time the engineers and other industrial leaders of the world will see that they owe something to their workmen besides wages, and something to the community besides cheap goods. They will realize that the real essence of life is not production but consumption, that beauty and contentment are quite as important during business hours as after them, and that unpleasant working conditions are just as indecent as are unsanitary ones. It might even "pay" to work along these lines; but it ought to be done as a social obligation whether it "pays" or not.

One important remedy for roving minds is already in existence and its effectiveness is rapidly increasing. I refer to adult education in home-study and correspondence courses, in night schools of art, law, business, and engineering, in trade schools of many kinds, and in classes in general or cultural subjects. The growth of this wholly admirable effort at voluntary self-improvement is a striking feature of current history.

As to the advertising mania, I can only say that I have an instinctive, though as yet unprovable, belief that it is, in the long run, economically unjustifiable from the point of view of society as a whole, however much it may seem to bring immediate benefit to individual industrial units. I look forward to the day, and may it come soon, when broad-minded engineers will attack the problems of distribution with the same vigor that they have heretofore lavished on production.

V

So MUCH for mass production as an impersonation of the machine age. But if we are to speak of the spirit of men, we ought also to speak of the spirit that lies behind, and has produced, the machine. The heart and soul of the machine age is affecting our spirit and culture quite as definitely and effectively as are that age's material manifestations and excrescences. The heart and soul of the machine age is the spirit of science. What is the spirit of science, and how is it changing the spirit and culture of the world ?

By way of contrast, let us look back into the beginnings of civilization. In his delightful book, "This Believing World," Lewis Browne suggests that the earliest religions of the world grew out of the spirit of fear. To the Neanderthal man, the environment was constantly hostile. Wild beasts endangered him. Storms brewed and beat upon him with rain or hail or chilling snow. Trees fell on him or across his path. Rocks and avalanches from the mountains above just missed his lair. Streams blocked his way or rose in flood to engulf him. Thunder and lightning and the still greater voice of the volcano, if one happened to be near, terrified him. Against all these natural phenomena he waged constant warfare. Small wonder that in his ignorance, but taking courage from such of his successes as impressed his memory, he seized on this or that fortuitous circumstance, and gradually built up a system of charms and talismans. Small wonder that he turned for guidance to witch doctors and medicine men who were, or at least pretended to be, less afraid than he. Small wonder that he read into rock and stream, into tempest and thunder, independent, living, purposeful personalities, like those of the hostile beasts and men that surrounded him, and created for himself spirits, demons, and gods. And small wonder that he tried to propitiate, to barter with, to bribe, or to terrify these gods with prostrations and flattery, with sacrifices and burnt offerings, with incantations and rites.

And then came the spirit of science whose instinctive reaction to the environment is to look it in the face, clear-eyed and unafraid, to attempt to understand rather than to propitiate it, to regard it not as an enemy but as an opportunity wherein, by enlightened and purposeful conformity, man can make the tremendous forces of nature work for his own good. The spirit of science looks outward, not backward, for its guidance and inspiration. It faces the facts and acts accordingly, rather than merely inquiring what grandfather or Thomas Jefferson or Marcus Aurelius did or said under similar, or apparently similar, circumstances.

All this has made, and is making, a tremendous change in the spirit of mankind. Our leaders already face the world about them with a totally new attitude of courage and self-reliance and buoyancy. We have harnessed the lightning and we are in the process of trying to harness the flood. Even the volcano and the earthquake are under close scrutiny in the hope that even if we cannot control them, we can at least mitigate to an extent the severity of their interference with our welfare.

Nor is the direct effect of the spirit of science on our material fortunes its chief potential significance. It is bound to penetrate far beyond the confines of what we ordinarily call science, that is, physics and chemistry and biology and psychology, even into such fields as economics and sociology and politics and philosophy and religion. In all these fields there will be an increasing number of leaders whose instinct it is to face the facts and in the light of them to forge out utterly new solutions for the many problems of mankind.

Nor will the influence of this new spirit of science be confined to the leaders in these various fields. More and more will it reach and fortify the average man; more and more will it change, gradually and imperceptibly, but inexorably, his whole philosophy of life; more and more will it give him spirit and culture to an extent as yet undreamed of. The process of carrying the spirit of science into the education of our youth is scarcely begun. Those who now lead civilization were for the most part trained under very different auspices. It will take at least another generation to weave the new spirit into the warp and woof of the thinking of average men. It will take, too, a lot of idealism and vision in the scientists and engineers and educators of the immediate future. But it will be among the noblest adventures of the human race.

VI

SOMETHING of this sort must have been in the mind of Emil Ludwig when he wrote, in the *American Magazine* for November 1929: "The century, above all else, determines what the exact nature of a man's activity shall be. In 1200 the man who wished to distinguish himself became a crusader, in 1500 a bandit, in 1800 an iconoclast, and in 1930 he will become an engineer."

Twenty years ago, when there was need of a wise and able man for a position of large responsibility in business or public life, the choice usually fell on a lawyer. And twenty years ago, when a young man of ability without predetermined ideas as to a career, desired a higher education, he naturally turned to a liberal arts college and followed it by a course in law, whether he expected to practise law or not. Which of these facts was the cause of the other is of little consequence for our purpose. Probably each had its influence on the other. Probably also the type of training common in law schools, and in particular the case system which was developed in the Harvard Law School, long before it found its way into other branches of education, had much to do with the matter. But in any case, the two facts remain as outstandingly true of the not-far-distant past.

If, however, I am right in the belief that the leaders of the future will be men imbued with the spirit of science, if Emil Ludwig is right that the adventurous career of the future is that of the engineer, there is certain to be a marked change in the nature of what might be called the standard liberal education of the coming years. Indeed I am inclined to think that the more progressive of the scientific and engineering schools of the present day are both nearer to, and progressing faster toward, the type of training that will be standard twenty years hence, than are many of the so-called colleges of liberal arts. The engineering schools are already full of the spirit of science, and while many of them still overemphasize the vocational, and underemphasize the human elements in training, there are already strong indications of a keen realization of these shortcomings and of concerted efforts to overcome them. It seems to be easier for men of science to desire a liberal background than for classicists to desire a scientific foreground.

This is why so many young men, about to graduate from high school, are saying to themselves, "When in doubt, select an engineering course." And this is why the engineering schools themselves are striving, as never before, to give well-rounded educations, in which history, literature, economics, and philosphy have their appropriate place. For however much the scientist distrusts the validity of tradition, precedent, or dogma *per se*, he is, nevertheless, keenly alive to the part that such a subject as history, whether it be the history of nations, of customs, or of philosophy, can play in stimulating intelligent thought about the problems of today and tomorrow.

VII

THE SPIRIT of science is already beginning to liberate the spirit of mankind, to demand and to provide a new philosophy of courage and optimism. How about culture? We have defined culture as that step, beyond obtaining subsistence, which brings the appreciation of beauty into life. Science has already played a tremendous part in making it easier for man to obtain subsistence. Food, shelter, possessions of all kinds are far more abundant and of far higher quality than ever before. But when it comes to the appreciation of beauty it would seem that the western world has never quite managed to outgrow the renascence.

Recently a teacher in one of the most progressive schools in the country published a little book of plays for young children. The impression that it made on another teacher in a still more progressive school is illuminating. "It's beautifully done," she said, "but have you noticed that every one of the plots came either from fairy lore or from classical or mediæval mythology? Apparently Miss X thinks that to find beauty she has to go back two hundred years."

And those of us who can remember the days when *The Nation* was publishing the best editorial writing in America, can hardly fail to recollect the wealth of classical allusion with which those gems were often embellished. Yet never was there the temptation to illuminate some point by an apt analogy from the field of science. Of course not! The writer didn't know any science. And even if he had, his readers could not have been counted on to know what he was talking about.

This state of affairs will not last indefinitely. Already artists are finding beauty in the structures that industry has reared. Already art is finding its way into industry, crudely perhaps, but none the less significantly. And, as the number of common men whose minds have been touched by the spirit of science increases year by year, and as the number and diversity of the problems of human life that are attacked in that spirit also increases, more and more there will grow up a new culture of the here and now, an appreciation of the beauty of a world of science, an enjoyment of the flavor of scientific thinking, a thrill the essence of which lies in a fuller understanding of the hows and whys of civilized life.

Nor will this new culture necessarily be more utilitarian or prosaic than the old, or less able to kindle the imagination, or to stir the emotions of men. I can conceive of nothing more soul-enlarging in Homer or Dante than the contemplation of the galaxy of stars that forms our milky way, and of our humble place in it, or of the many other similar galaxies that are known to surround ours, or of the other galaxies of galaxies that astronomers are already beginning to describe with some assurance. Just as much does it stretch our minds, and thrill them too, to turn to the incredibly small, and become acquainted through the help of modern physics with what goes on inside atoms, with how the stuff of the world is put together, and perhaps, through cosmic rays, with how and where the process of putting it together is actually going on at this present moment. Such thoughts as these share the grandeur of the first chapter of Genesis, and have a noble cultural value if only we can develop ourselves to appreciate it.

This is, perhaps, the greatest adventure ahead of scientists and engineers, to build up this new culture based on the spirit of science, which shall not supplant, but rather supplement and extend the culture of our forefathers and ourselves.

XVI — SUMMARY — THE PLANNING OF CIVILIZATION

By CHARLES A. BEARD

IT WOULD be undesirable, even were it possible, to attempt to summarize here the views of the engineers and scientists expressed in the preceding pages. Moreover, owing to the limits of space, our authors have not been able to cover all the facets of their several specialties. Many themes are of necessity omitted. Many phases are left untouched. Yet when these papers are surveyed as a whole, when their data and implications are brought to a focus, certain outstanding features and a common spirit engage the attention.

Nothing is more apparent than the fact that these writers, though immersed in their laboratories or engaged in work of a highly technical character, are fully aware of the criticisms brought against machine civilization in the name of humanism, religion, and æsthetics. They are also fully aware of the evils and maladjustments connected with the development of science and machinery. No wall separates "the engineering mind" from the cultural heritage in which it operates. It works within the limits of our transmitted intellectual outfit and it evolves in the process, assimilating materials and ideas from all sides.

Quite rightly our authors ascribe many of these evils to the unpreparedness of the people for a technical revolution so vast and so varied in its potentialities. But this insistence on a division of responsibility is not followed by an evasion of issues, nor a retreat to discarded modes of dogmatic thought. Indeed one note runs through all the chapters: the revolution wrought by science and machinery is not completed; it has just started and its immense possibilities are only beginning to be appreciated; hence a free and easy condemnation out of hand by critics who know nothing of its inner processes and potentialities is bound to be at best superficial. Besides showing that the new drama of mankind has just opened, our authors demonstrate that the spirit of engineering is rationality, a faith in the power of the scientific method to undo what should never have been done and to realize whatever human imagination may suggest in the way of material and social arrangements.

Nowhere in these pages is there any engineering dogmatism; indeed in more than one place dogmatism is described as the foe of science and invention, "the enemy" in fact. To put the matter in a positive form — almost in the words of President Hoover — our authors say: "Let us face all the pertinent facts available, frame our designs to meet our ends conceived in the highest possible terms, make the calculations, and construct to purpose." This method, they argue, is applicable within limits to all the problems of civilization raised in the Introduction. Hence it is clear that engineering can perform what Matthew Arnold calls the supreme intellectual feat: it can turn in upon itself, can explore its own processes and achievements and possibilities, with its own method — rationality illuminated by imagination. If, as alleged, certain objectionable spiritual and æsthetic evils have flowed from the material operations of the machine — and this is the burden of the complaints against it — then engineering offers a way or ways out of the dilemma. It is here contended that in a large measure the evils and discomforts of the modern age have come, not from the rationality of engineering, but from a failure to exercise it intensively enough and to apply it in enough directions. Not to a surrender of the rational or planning method do these engineers look for achievements, but to an extension of it into other domains — even æsthetics.

Coming to the central question respecting the power of engineering to produce the highest type of civilization, our authors correctly shift some burdens to other shoulders. But if, as repeatedly insisted, slavery, which releases a large number from drudgery, was the very foundation of Greek civilization, then it can be said that engineers have laid a wider and better basis for civilization in America. To those who complain that engineering has divorced life from the handicraft arts, the reply may be made that this divorce, through release from drudgery, was even more marked in the case of the thinkers who gave Athens her chief intellectual glory. If civilization has an economic foundation — and it has — then engineering has provided the most extraordinary substratum for a civilization ever conceived. More than this. It has provided a method of rationality — an instrument — for carrying that civilization toward heights that are staggering to the imagination. But only those who work at and in technology sympathetically and understandingly can discover and achieve its potentialities.

Of course, this concept of rationality, of deliberate and informed planning, to grand ends is not entirely new. More than two thousand years ago Plato laid out in his Republic a scheme for what appeared to be a rational society. When Aristotle rejected this utopia as chimerical, he did not cast aside all thought of conscious order and design in the creation of civilization. On the contrary, in his searches among the actual constitutions of many Greek states, he found, not chaos merely, but evidences of a certain conformity to pattern, as if statesmen and planners were more or less consciously evolving, under unknown law, a rational order out of primeval confusion. To forward that constructive process was one of the great objects to which Aristotle directed his intellectual labors, amid great discouragements, no doubt.

These two concepts — utopia and actuality, supplementary and yet contradictory, have never been surrendered. And now engineering comes with a method and equipment which are essentially rational, founded on planning, on the assumption of law. By inherent necessity it forces upon society an ever larger planned area of conduct; by its method it indicates how still larger domains can be conquered. It offers to Aristotle's statesman and planner an opportunity and a power never before granted them in the history of the world. It clears the way, it removes obstacles, it shows how mankind may be released from slavery to material circumstances, it offers to humanity an instrument which in its power and its infinite possibilities is more worthy of gods than men. It believes that it has a method by which men may become far more creative than the ancient divinities of Athens.

In strict truth, only for a brief moment and on a small part of the earth's surface has it been held by any considerable number of thinkers that mankind can make a civilization without the rationality and method of engineering. In England, about the middle of the nineteenth century, the Manchester philosophers maintained, in effect, that the best life would come to all if each individual would simply pursue his own interest without reference to large, controlling designs — as it were, follow his own nose under the propulsion of the acquisitive instinct. These philosophers were not without ideals. In fact, they believed that a splendid pattern of world civilization would be automatically created when their specific remedy was generally used. As things turned out, however, Plato and Aristotle came nearer divining the historic process, accelerated by the engineer, than did Richard Cobden and John Bright.

When engineering spread from the isolated plant to national and even international industries, when it was forced to assume responsibility for management as well as operation, the nose-following utterly broke down as a scheme of action. Wherever facts, designs, and calculations must control with a view to the production of results, then instincts, chance, and guess-work are outlawed. No task — economic or æsthetic or moral — calling for large operations can be undertaken on the basis of uninformed, uncoördinated instincts or a mysterious higher will.

As science and engineering occupy an ever larger area of industry, business enterprise takes on the spirit of rationality. It cannot stake anything important on chance, or unknown possibilities of materials, costs, and markets. It must, it does, organize internationally in trusts and cartels, make budgets, and adapt its operations to predetermined ends. There may be room in minor enterprises for "happy inspirations," lucky guesses, and individual idiosyncrasies, but not in the prime branches of grand economy. Throughout the whole world of economic operations runs the imperative necessity of planning, of rationality, in the engineering sense. And that rationality bears upon human as well as material factors. Nobody as yet has the faintest idea of the limits upon this mode of procedure.

Nor can government and society as a whole escape the impact of this planning process. Engineering rationality is the staff of industry, it runs into business, and inevitably into government and social arrangements. These too are founded on an economic base and are involved, by the nature of things, more or less intimately in the operations of productive economy. Thirty years ago, city planning was almost unknown in the United States, at least as an organized science; now that interest is represented by a national association, a magazine, a national conference, university chairs, practising professions, volumes of statutes, and achievements of no mean order. Yet it stands merely at the beginning of its career. Hard upon this development comes regional planning. State planning creeps up over the horizon. The word has scarcely stolen into the regular vocabulary of Washington politics, but national planning is implicit in innumerable works of the federal government, in the effort of the Farm Board to coördinate agricultural production, in the action of President Hoover when he called upon leaders of all branches of national economy to coöperate in holding production to a steady level of performance. The higher the degree of rationality in all this planning, the less the necessity for coercion, the greater the appeal to reason.

The planning which dominates engineering, spreads out into industry, and creeps into government and society does not stop at the borders of æsthetics. On the one side, no doubt, it sets material limitations to the movement of æsthetics; neither it nor any other mode of production in itself has supplied the æsthetic impulse. Material conditions, however, have always circumscribed æsthetics, in the pre-engineering age more severely than in our own time. As a matter of fact, engineering and science extend material limits in both directions: microscopic and gigantic. If æsthetes prefer to hold to the small and precious, they may do so now with a scientific equipment that makes possible a still greater manipulation of the minute, but on what ground can they scorn the gigantic? It may be said that the Creator himself has taken no such pettifogging view of the universe. Why should there be virtue in size, either small or large? With some justice, engineers may retort that if æsthetics cannot rise to the new situation, it suffers from inherent weakness and lack of imagination. At all events, in its work of creation, engineering supplies innumerable forms of beauty and in its mastery over materials it makes possible æsthetic operations transcending all previous experiences of the race.

As in the case of æsthetics, so in ethics, engineering, dominated by rationality, carries with it inevitably certain necessary forms of conduct adapted to its requirements. As such it does not offer a system of ethics; even the various branches of the engineering profession have not yet explored all the ethical implications of their work; nor has it developed its professional code. But the writers in this volume are trained in science and engineering, and all through their chapters are powerful evidences of an ethical sense, informed by their work and experience. Every one of them is alive to the human factors involved in his operations — to the fundamental problem of the standard of life, not for any narrow class but for the countless millions left out of previous pictures of civilization. As the engineers' profession develops from specific operations under an immediate physical load to management in the large, the range of their ethical interest widens. Specialized ethics will integrate as the profession expands and integrates. Like every new profession, confusion may exist on the frontiers, but ever larger domains of conduct will be occupied by the method of rationality. As the Church Fathers rationalized the best elements of the feudal order and idealized them, so it may well be argued by analogy that masters of the new technology will seize upon, rationalize, and idealize the best elements of their order. This seems to be inescapable. The task of the latter will be infinitely more difficult because they are dealing not with a static pattern of human affairs but with experience open at both ends and in a process of constant evolution. Yet proof of the beginnings are expressed or implicit on nearly every page of this volume.

No small part of the difficulty in formulating ethics in the engineering age is due to the heritage of the preceding agricultural age — to the fear and inordinate acquisitiveness necessary to primitive man living constantly in the peril of starvation. Engineering has made practicable the utter extermination of that fear, as our authors have emphasized, and when that is once accomplished a new basis of human relations will be laid. And with that achievement a new civilization will be erected, with ethical potentialities inconceivable under the economy of a perilous and marginal life. Moreover in the scientific method lie possibilities of plan and control — a kind of plan and control which neither feudal Europe nor classical antiquity possessed, for the lack of which, perhaps, their civilizations dissolved. More engineering, not less, engineering informed with respect to its human implications, controlling unlimited power, mastering the nature of materials, adapting them to mankind and mankind to them, conscious rationality triumphant, not as purpose only but also as an instrument worthy, as Zschwimmer has said, of "conquerors by the grace of God."

In all this there is no ineluctable bigotry. If in the old contest with the dogmas of the churches, science and engineering took on the dogmatic tone inherited from the ages, that note does not characterize this volume. Above all things, these writers, chosen by a committee of engineers, are in an inquiring and receptive mood. If they are firm in stating facts, they are as eager as professional humanists to explore the widest implications of their work. While engaged in helping to make this machine civilization, they are indifferent to none of mankind's enduring values, but are trying to work them into the materials of life, to find guidance in them.

Yet out of experience they have become convinced of the inescapable reality of the processes now under way. They see no signs of a return to the caste cultures of handicrafts and agriculture, but rather a movement toward another civilization incompatible, by its intrinsic nature, with caste philosophy, literature, and art. This new civilization will not be ashamed because millions have material goods which were once the monopoly of "the civilized minority," as it has called itself; but that will not be its entire case. It will summon out of mankind all the manifestations of the spirit which have given richness to the ages of the past, but those who achieve great results in the sphere of the humanities in this order must first submit themselves to the discipline of science and engineering before they can discover potentialities of our time for the nobler arts of living. If as Nietsche says, "only the strong can endure history," then it may be said with equal force that the future belongs only to the resolute — the resolute equipped with engines of power greater and more mysterious than ever served artists and architects of old.

While refusing to accept any defeatist philosophy or to take refuge in any escape, our authors display no contempt or scorn for other societies and civilizations. Far from it. They distinctly recognize the merits and charm of the limited class régimes of the past, with luxury, poise, grace, beauty, gentility, and quality for the chosen few at the top, with arts appropriate in form, dignity, and style. They have no quarrel with such orders as historic facts and in their places, as the products of conditions of life and work that are not ours. But they cannot see why it is nobler in mind to attempt the impossible task of reversing a world process and returning to a dead past than to take up the inviting enterprise of creating out of materials in hand a more magnificent future.

This future they do not identify with historic capitalism in its crude form, indifferent to the wages, hours, and conditions of employment prevailing among those who labor at machines. What they say is that science and engineering have solved the problem of production, have brought the abolition of undeserved poverty and misery within the range of the practicable for the first time in human history. And those who have wrought this miracle are now deeply concerned about the next stage — a wider distribution of wealth and a nobler use of riches and leisure. Our authors do not merely concede that great work remains to be done or merely express a pale hope for the best. They point to tendencies now visible, to movements already in strong current, to achievements that are being accomplished in the making of a better civilization.

It is difficult to discover any value ardently desired by the critics of machine civilization which these engineers and scientists do not likewise desire. Is it leisure? They propose to make it more universal. Is it the good life? They will provide the necessary material conditions to make it more abundant. Is it beauty? They insist upon fostering the love of it and incorporating it into the daily lives of millions. Is it truth? They propose to pursue it, not merely within the confines of historical categories, but wherever it may lead in this mysterious world of substance and power. Is it anything covered by the term humanity — fair dealing, toleration, freedom from pain and suffering, relief of misery, succor for them that are hungry and athirst, aid for the weak and afflicted, guidance for the stumbling? They propose to use the engines of science and invention to fortify, speed up, and multiply the agencies of humanity.

And what of religion? As a system of dogmas respecting the supernatural, these writers pass it by; they do not here pretend to penetrate its high mysteries. Where religion has anything to present in terms of human conduct and welfare, they are concerned with it. They offer to the professors of religion instrumentalities for giving effect to their ethical impulses beyond all historic imagination. Is a saint more of a saint because he rides in an ox cart, rather than in an automobile or airplane, to spread the gospel or to do good to them that are sick and in prison? If doing good is a great good, both temporal and spiritual, then the use of agencies that multiply it should not detract from the virtue, even if they do not add to it. On what conceivable philosophy can a contrary case be founded?

Finally we come to the all-embracing indictment of those who call themselves "humanists," claim a monopoly of the true virtues, and seem to be arraying themselves against American civilization as "materialistic." We are told by a spokesman of this school, Irving Babbitt, that "there is an increasing number of persons in this country who can at least see the point of view of the rest of the world. This point of view may be defined as a curious blend of admiration for our efficiency and disdain for our materialism." Now humanism is "in general any system of thought or action which assigns a predominant interest to the affairs of men as contrasted with the supernatural or abstract. The term is especially applied to that movement of thought which in western Europe in the fifteenth century broke through the mediæval traditions of scholastic theology and philosophy and devoted itself to the rediscovery and direct study of the ancient classics. This movement was essentially a revolt against intellectual, and especially ecclesiastical, authority, and is the parent of all modern developments whether intellectual, scientific, or social." Correctly understood, humanism is primarily concerned with the affairs of mankind as distinguished from anything savoring of scholastic theology; and in a strict sense this volume by engineers and scientists is a humanist document. If reference is made to the great "virtues" of humanism, as expounded by Mr. Babbitt, namely, "moderation, common sense, and common decency," these writers reject none of them, but prefer rather to explore their content as applied to practical affairs. If reference is made to that "higher will," which Mr. Babbitt insists on reintroducing into humanism, as engineers and scientists, our authors are not concerned with it; in this case the Editor may add that the subject belongs to abstract theology from which humanism, as correctly defined, the parent of science and engineering, declared its independence centuries ago. For the pitifully limited humanism of the fifteenth century, our authors offer a humanism of science and engineering that has multiplied the powers of mankind to deal intelligently with human affairs far beyond the dreams of those who rescued the classics from the deadly grip of scholasticism. This is no "new" humanism, it is the old "system of thought and action," developed and applied with fearless imagination.

Imagination is the correct word. Science and engineering do not reject it and substitute mere logarithmic tables or routine mechanical procedure. Although our authors recognize the significance of that marvellous instrument of the modern mind — the invention of invention, although they rely upon it for making immense advances in the future, they still find that electric fluid, imagination, absolutely essential to the achievement of results in the realm of the unexplored and unprecedented. Without it, science and engineering become dogmatic and sterile. It must be and is being cultivated and nourished as one of the essential forces of the modern world. Imagination, informed by the known laws of nature, but unbound and free to experiment and dare, combined with the spirit of rationality, lives and flowers in the engineering age and will swing new planets into the ken of those who watch the heavens for signs of the future.

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